REPUBLIC OF THE UNION OF MYANMAR
MINISTRY OF CONSTRUCTION
DEPARTMENT OF BRIDGE

DETAILED DESIGN STUDY ON THE BAGO RIVER BRIDGE CONSTRUCTION PROJECT

FINAL REPORT

Summary

DECEMBER 2017

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
METROPOLITAN EXPRESSWAY COMPANY LIMITED.
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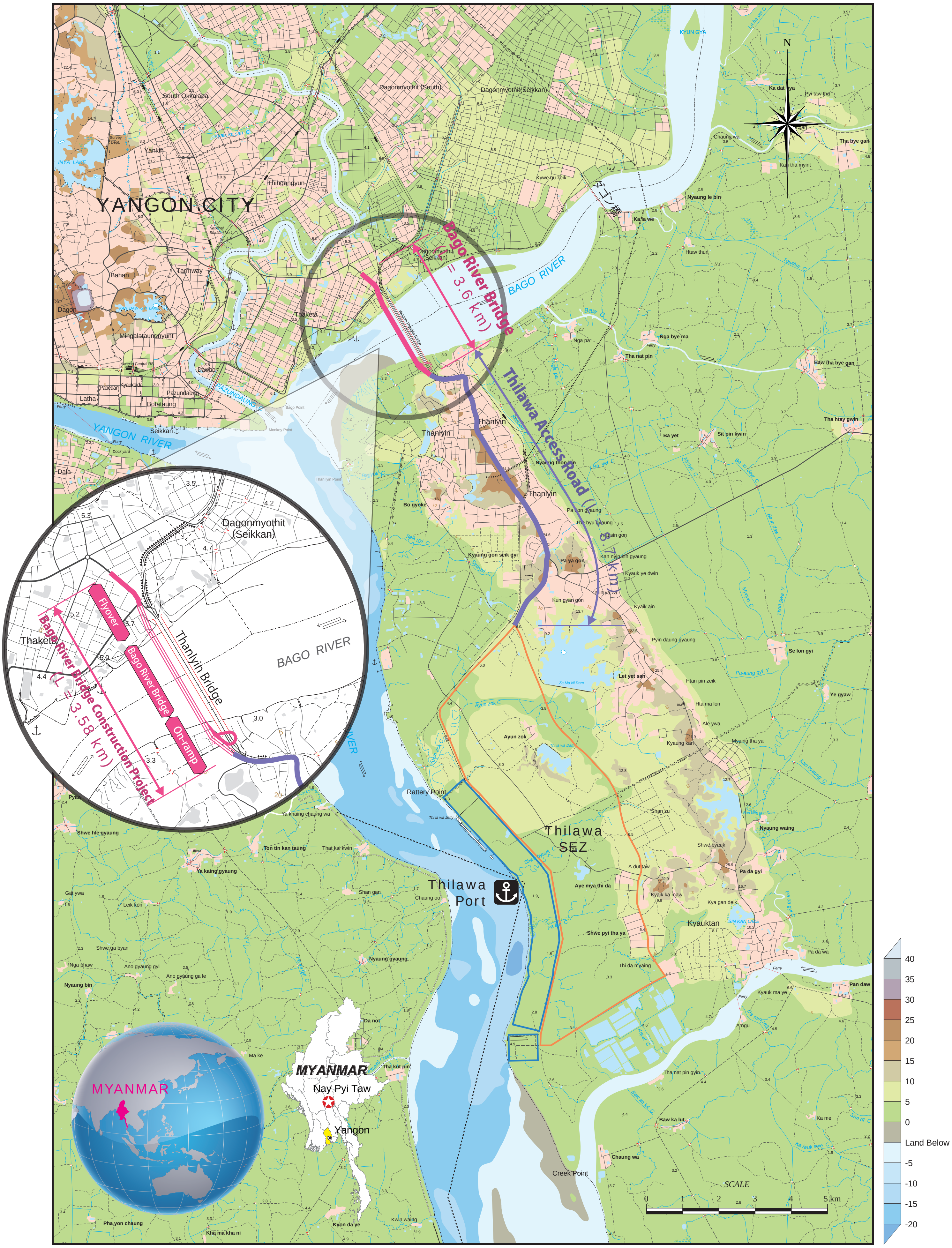

Location Map of the Project

Perspective of the Project (Bago River Bridge)

Perspective of the Project (Bago River Bridge)

Perspective of Cable-stayed Bridge

Perspective of Cable-stayed Bridge

Perspective of On-ramp (Thanlyin Side)

Perspective of Steel Box Girder Bridge

Perspective of the Project (Thaketa Side)

Perspective of Flyover Bridge (Thaketa Side)

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AIDS	Acquired Immune Deficiency Syndrome
A-RAP	Abbreviated Resettlement Action Plan
ASEAN	Association of Southeast Asian Nations
B/D	Basic Design
BD/R	Basic Design Report
BRT	Bus Rapid Transit
CBD	Central Business District
COD	Cut-off Date
CS	Construction Supervision
D/D	Detailed Design
DF/R	Draft Final Report
DMH	Department of Meteorology and Hydrology
DMS	Detailed Measurement Survey
DO	Dissolved Oxygen
DOB	Department of Bridge
DOH	Department of Highway
DOL	Department of Labor
DWIR	Directorate of Water Resources and Improvement of River Systems
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
F/R	Final Report
F/S	Feasibility Study
GAD	General Administration Department
GOM	Government of Myanmar
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
IC/R	Inception Report
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
JSHB	Japanese Specifications for Highway Bridge
L/A	Loan Agreement
MFSD	Myanmar Fire Services Department
MMK	Myanmar Kyat
MOC	Ministry of Construction
MONREC	Ministry of Natural Resources and Environmental Conservation
MOL	Ministry of Labor, Immigration and Population

MOTC	Ministry of Transport and Communications
MPA	Myanma Port Authority
MR	Myanmar Railways
MRT	Mass Rapid Transit
NAP	National Aid Program
NEXCO	Nippon Expressway Company
NO2	Nitrogen Dioxide
ODA	Official Development Assistance
O&M	Operation and Maintenance
PAHs	Project Affected Households
PAPs	Project Affected Persons
PC	Prestressed Concrete
PC-T	Prestressed Concrete T-shaped
PM2.5	Fine particulate matter 2.5
PMU	Project Management Unit
ROW	Right of Way
RTAD	Road Transport Administration Department
Rd	Road
SEZ	Special Economic Zone
SO2	Sulphur Dioxide
SPSP	Steel Pipe Sheet Pile
SPT	Standard Penetration Test
SUDP	The Strategic Urban Development Plan of the Greater Yangon, JICA (2013)
Supplemental F/S	Supplemental Feasibility Study
SV	Supervision
TOR	Terms of References
TS	Total Station
USD	US Dollar
WB	World Bank
YCDC	Yangon City Development Committee
YESC	Yangon Electricity Supply Corporation
YRDC	Yangon Region Development Committee
YRG	Yangon Region Government
YUTRA	Project for Comprehensive Urban Transport Plan of the Greater Yangon

CHAPTER 1. GENERAL

1.1 INTRODUCTION

The Greater Yangon, which consists of Yangon City and its surrounding townships, has a population of 7.3 million (2014) and is the economic center of the growing Myanmar. Being the center of the economic activities in Myanmar, Yangon City faces excessive centralization accelerated by recent rapid economic growth, generating transport demand larger than ever. The present transport infrastructure is not enough to sustain the rapid development of the economy.

The economic activities of Yangon have been expanding outwards including development of new towns, satellite towns, industrial zones, and green and reclamation. The development in land use and its expansion are making sub centers surrounding the central business district (CBD) including, Hlaing Tharya, Mindama, Dagon Myothit, Dala,Thanlyin, and Thilawa. These development and expansion in future land use can be effectively supported by transportation enhancement including arterial roads, outer ring roads, railways, MRT, and BRT, as defined in the Strategic Urban Development Plan (SUDP) of the Greater Yangon, JICA (2013).

In the next twenty years, person trips will be increased drastically, in particular, between Thilawa and Yangon CBD mainly due to the development of Thilawa Special Economic Zone (SEZ). As a result, the area needs high-order transit services that will be expanded.

Similarly, logistics traffic between Yangon CBD and Thilawa will also increase, exhibited by the number of truck traffic as shown in this slide. The truck traffic demand between Thilawa and CBD crossing Bago River will be increased by three times. The truck traffic between Thilawa and Bago Subcenter crossing Bago River is also similarly increased.

As a result, new bridges crossing Bago River are needed in the near future to accommodate the bigger traffic demand.

Currently, there are two existing bridges connecting Yangon CBD and Thilawa crossing Bago River, which are Thanlyin Bridge and Dagon Bridge. Comparing the two bridges on current traffic volume, the traffic volume on the Thanlyin Bridge route is much more because the Dagon Bridge route has a longer distance and narrower access roads. Similarly, majority of traffic between Bago Subcenter and Thilawa passes Thanlyin Bridge and the Thanlyin Bridge route is the access between Thilawa and CBD or Bago Subcenter.

Thanlyin Bridge has two major problems for accommodating such big traffic demand in the near future: the number of lanes and weight limitation. The bridge has only one lane on each direction which is vulnerable to terrible congestion by only a small incident like a tiny trouble of a vehicle. The bridge has weight limitation of 32 tons, which cannot accommodate heavier trucks like large trailers.

Therefore, the necessity of constructing a new bridge over the Bago River is one of the high priorities in Myanmar’s development agenda. The Strategic Urban Development Plan of the Greater Yangon (SUDP) (2013) and the Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA) (2014) have been published under Japanese assistance. These master plans clearly pointed out the inadequate transport infrastructure between Yangon City and Thanlyin Township. The construction of Bago River Bridge will surely guarantee the expected economic growth in Thanlyin Township, with acceleration of Thilawa SEZ development, and thus contribute to the economic development of the whole of Myanmar.

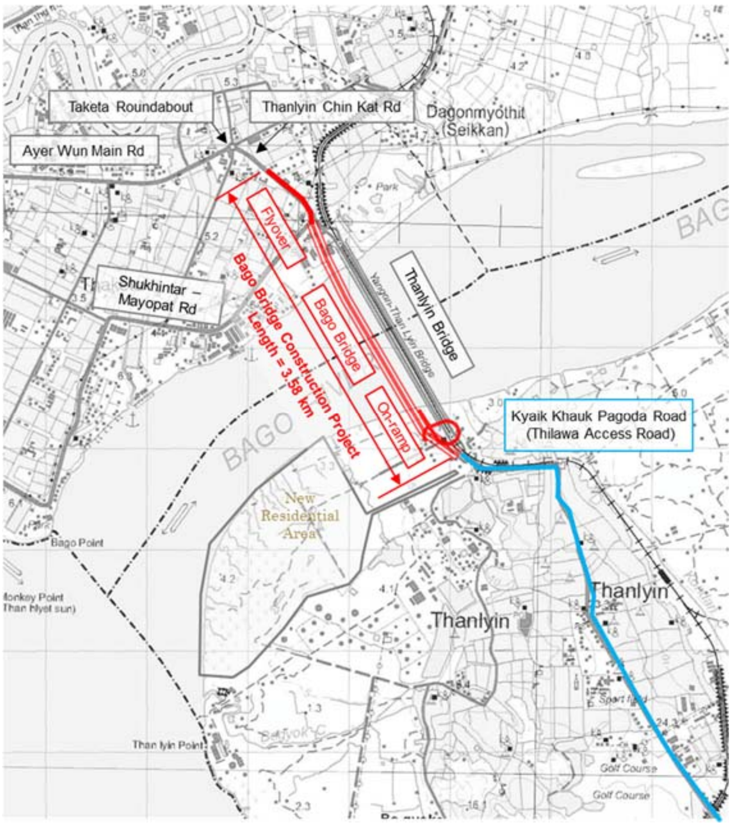
Therefore, the construction of a new bridge, i.e., Bago River Bridge (hereinafter referred to as “the Project”), is urgently required.

As stated in the minutes of the meeting between the Ministry of Construction (hereinafter “MOC”) and the Japan International Cooperation Agency (hereinafter “JICA”), signed on May 15, 2013, a preparatory survey was conducted for the feasibility study on the new construction of Bago River Bridge and approach road to the bridge and the final report was submitted on August 31, 2014, which was accepted by MOC. The preparatory survey was followed by a supplemental survey conducted in February 2016 for studying improvement of the adjacent intersections and connecting roads, and updating the traffic demand forecast, cost estimate, environmental and social considerations, and project evaluation.

Based on the results of the preparatory surveys, the Government of Myanmar secured a loan from JICA for the Project.

1.2 STUDY AREA

The study area is located in-between and surrounding Thanlyin Chin Kat Road in Taketa Township and the north end of Kyaik Khuk Pagoda Road in Thanlyin Township, Yangon, the Republic of the Union of Myanmar.



Source: JICA Study Team

Figure 1.2.1 Study Area

1.3 OUTLINE OF THE DESIGN STUDY

1.3.1 Title of Design Study

Detailed Design Study on Bago River Bridge Construction Project

1.3.2 Objectives of Design Study

The objective of the Design Study is to prepare the detailed design and draft tender documents for the Project. The Department of Bridge (DOB) of MOC and JICA confirmed that the drawings and documents formulated by the Design Study (hereinafter referred to as "the Design Documents") shall be fully utilized for the procurement procedure of the Project.

1.3.3 Project Profile

(1) Name of the Project: Bago River Construction Project

(2) Signing L/A: March 1, 2017 (MY-P16)

(3) Proposed Facilities of the Project

The proposed facilities of the Project are shown in Table 1.3.1.

Table 1.3.1 Proposed Features of the Project

No.	Item	Package 1	Package 2	Package 3
1	BP	STA 0+000, Boundary of Thilawa Access Road	STA 1+312.0, Pier (P) 13 (P13: Package 1)	STA 2+676.0, (AF1: Package 3)
2	EP	STA 1+312.0, Pier (P) 13 (P13: Package 1)	STA 2+676.0, Abutment AF1 (South Abutment of Flyover: Package 3)	STA 3+644.3, Connect Thanlyin Chin Kat Road to Thaketa Roundabout
3	Length	1,312.0 m	1,364.0 m (1,424.0 m)	968.3 m
4	Road Desig Standard/ Class	Equivalent to Road Class in Japanese Road Structure Ordinance, and ASEAN Highway Standard Type 2 Class 1	Type 2 Class 1	Type 4 Class 1
5	Design Speed	60 km/hr: Main carriageway 30 km/hr: On-ramp	60 km/hr: Main carriageway 30 km/hr: On/off ramps (frontage roads)	60 km/hr: Flyover bridge 40 km/hr: Road at-grade
6	Nos. of Lane	Four lanes: Main Carriageway One lane: On-ramp	Four lanes: Main Carriageway Two lanes: On/off ramps (frontage)	Two lanes: Flyover bridge 2 x two lanes: At-grade roads
7	Overall Road Width	19.0 - 20.7 m: Approach road 20.7 m: PCa PC box girder bridge 22.9 m: Stay-cable bridge 6.25 m: On-ramp	20.7 m: Steel box girder 20.7 m: PC box girder bridge 53.2 m: Toll Gate	12.75 m: Flyover & approach road 11.5 m: At grade roads
8	Cross Section Elements	0.6+1.5+2@3.5+0.5+3.7+0.5+2@3.5+ 1.5+0.6: Cable-stayed bridge - Carriageway : 4@3.5 m = 14.0 m - Shoulder : 2@1.5 m = 3.0 m - Median : 4.7 m - Barrier : 2@0.6 m = 1.2 m	0.6+1.5+2@3.5+0.5+1.5+0.5+2@3. 5+1.5+0.6: Steel box girder - 4@3.5 m = 14.0 m - 2@1.5 m = 3.0 m 2.5 m - 2@0.6 m = 1.2 m	0.5+1.5+3.5+1.75+3.5+1.5+0.5 : Flyover - 2@3.5 m = 7.0 m - 2@1.5 m = 3.0 m 1.75 m - 2@0.5m = 1.0 m
9	Intersections, Ramps and Toll Gate	One (1) interchange and one (1) ramp <u>Intersection: STA 0+030</u> - Signal with 4 directions <u>On-ramp: STA 0+607</u> - 3.25 m wide 1 lane with shoulders (0.75&1.25) - 115.2m (4@28.8 m) long bridge PC-T Girder (Composite Slab Deck)	Toll gate and on/off ramps (frontage roads) <u>Toll Gate: STA 2+500</u> - 10 lanes with 9 booths, - management office building <u>On/off ramps (frontage roads)</u> - 3.5 m wide two lane with 1.5 m width	Two interchanges <u>Shukhinthar Intersection</u> - Signal with five directions <u>Yadanar Intersection</u> - Signal with four directions
	Diversion or Widening		<u>Diversion to Thanlyin Bridge</u> - 3.5m wide two lanes for on and off	<u>Widening of Thanlyin Chin Kat Road</u> - 2.0+1.5+2@3.5+0.5+0.5
10	Bridges	Total Length: 955 m <u>Nos. of Spans</u> - 11 spans (Abutment (A) 1 to P13) <u>Superstructure</u> - PC Box Girder: 5@50=250m - Steel Box Girder: 2@76.5+104=257m - Cable-stayed bridge: 112 +224 +112 =448m <u>Substructure</u> - Reinforced Concrete (RC) Pier <u>Foundation</u> - Land: RC Bored Pile (D=2.0m,1.5 m) - River: Steel Pipe Sheet Pile (D=1.2 m)	Total Length: 1,076 m <u>Nos. of Spans</u> - 13 spans (P13 to A2) <u>Superstructure</u> - Steel Box Girder: 6@122+104= 776m - PC Box Girder: 6@50 =300m <u>Substructure</u> - RC Pier <u>Foundation</u> - Land: RC Bored Pile (D=2.0m, 1.5 m) - River: Steel Pipe Sheet Pile (D=1.2 m)	Total Length: 602 m <u>Nos. of Spans</u> - 16 spans (AF1 to AF2) <u>Superstructure</u> - PC-T Girder (Composite Deck Slab): 2@30=60m, 6@30=180m, 2@30=60m - Steel Box Girder: 55+70+55 =180m - Steel Plate Girder: 35+52+35 =122m <u>Substructure</u> - RC Pier <u>Foundation</u> - RC Bored Pile (D=1.5 m)
11	Pavement Structure	<u>Bridge Deck</u> <u>PC Box Girder, PC-T Girder (Composite Slab Deck)</u> - Coarse 40 mm + Dense 50 mm <u>Steel Girder, Steel Cable-stayed Bridge</u> - Stone Mastic Asphalt 40 mm+40 mm	<u>Approach Road</u> - Subbase 250 mm + Base 200 mm - Binder 50 mm + Surface 50 mm <u>Toll Gate</u> - Subbase 250 mm + Base 100 mm - Concrete Pavement 250 mm	
12	Auxiliary Works	Drainage system, road lighting system, illumination system, obstruction lights, bridge bearings, expansion joints, navigation signs, road signs, road markings, inspection access, monitoring system, supports for water pipes and telecom fibers, signals, etc.		

** Japanese Government Order on Road Design Standards*
Source: JICA Study Team

1.4 WORK SCHEDULE

The entire work period of this detailed design study is approximately 17 months, including technical transportation program. The preparatory works were carried out from the middle of September 2016, the final report for the detailed design study will be submitted in early December 2017, and the main technical transportation program will be carried out from the middle of October 2017 up to the end of February 2018, as shown in Table 1.4.1. The time schedule for design change due to the revision in span arrangement is shown in red in the table.

Table 1.4.1 Work Schedule

Works \ Month	2016				2017												2018		
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
									Rainy Season										
Stage 1 : Preparatory Works																			
【1】Review of Existing Information and Data																			
【2】Preparation of Plan of Study																			
【3】Preparation of Inception Report (IC/R)																			
【4】Explanation of IC/R																			
【5】Review of Previous Studies based on Site Reconnaissance																			
Stage 2 : Basic Design Phase																			
【6】Field Surveys																			
【6-1】Geological Survey																			
【6-2】Topobraphic Survey																			
【6-3】Material Source Survey																			
【6-4】Hydrological Survey																			
【6-5】Utility Survey																			
【7】Basic Design																			
【7-1】Establishment of Design Concept and Design Criteria																			
【7-2】Basic Design																			
【7-3】Preparation of Outline of Construction Plan and Schedule																			
【7-4】Study and Preparation of Procurement Plan																			
【7-5】Update of Preliminary Project Cost																			
【8】Preparation and Explanation of Basic Design Report (BD/R)																			
Stage 3 : Detaield Desgin Phase																			
【9】Detailed Design																			
【9-1】Road Deisign																			
【9-2】River Bridge Deisgn																			
【9-3】Flyover Design																			
【9-4】Soft Soil Treatment Design																			
【9-5】Toll Collection Facility Design																			
【9-6】Lighting and Wiring Design																			
【9-7】Construction Planning																			
【9-8】Study on Safety in Construction																			
【9-9】Prepalation of Material Procurement Plan																			
【9-10】Cost Estimate																			
【10】Design Verification																			
【11】Operation and Maintenance Planning																			
【12】Preparation of Draft Bidding Dorcuments																			
【12-1】Preparation of Technical Specifications and BOQ																			
【12-2】Preparation of Draft Bidding Documents																			
【12-3】Explanation of Draft Bidding Documents																			
【13】Preparation of HIV/AIDS Prevention Program																			
【14】Preparation of Draft Final Report (DF/R)																			
【15】Explanation of DF/R																			
【16】Support on Project Promotion																			
【17】Preparation and Submission of Final Report (F/R)																			
Stage 4 : Environmental and Social Considerations																			
【18】Support on Environmental Considerations																			
【19】Support on Social Considerations																			
Stage 5 : Technology Transfer																			
【20】Technical Transfer on Bridge Design																			
Technical Advisory Committee	○		○	○	○			○		○		○		○					
Tender/Construction															□ Bidding				
Reports: ①IC/R ②BD/R ③DF/R ⑪F/R ⑫Promotion Movie		①			②						⑫			③		⑪			
Bidding Documents: ④Floyver Section (Draft) ⑤River Bridge Section (Draft)											④			⑤					
Environmental and Social Considerations: ⑥EIA Report ⑦A-RAP Report													⑥ ⑦						
Technology Transfer(TT) ⑧IC/R for TT ⑨IT/R for TT ⑩F/R for TT													⑧			⑨		⑩	

Legend: ■ In Myanmar □ In Japan ■ Design Change(In Japan)

Source: JICA Study Team

CHAPTER 2. FIELD SURVEYS ON NATURAL AND EXISTING CONDITIONS

2.1 SOIL INVESTIGATION

2.1.1 Survey Scope and Purpose

(1) Survey Purpose

Soil investigation was conducted in obtaining the geological and geotechnical information required for the detailed design of roads and bridges construction.

The main purposes of this survey are as follows:

1) To clarify the geological conditions, geological strata and their characteristics, of the construction site for detailed design; and

2) To determine geotechnical properties of the strata at the project site.

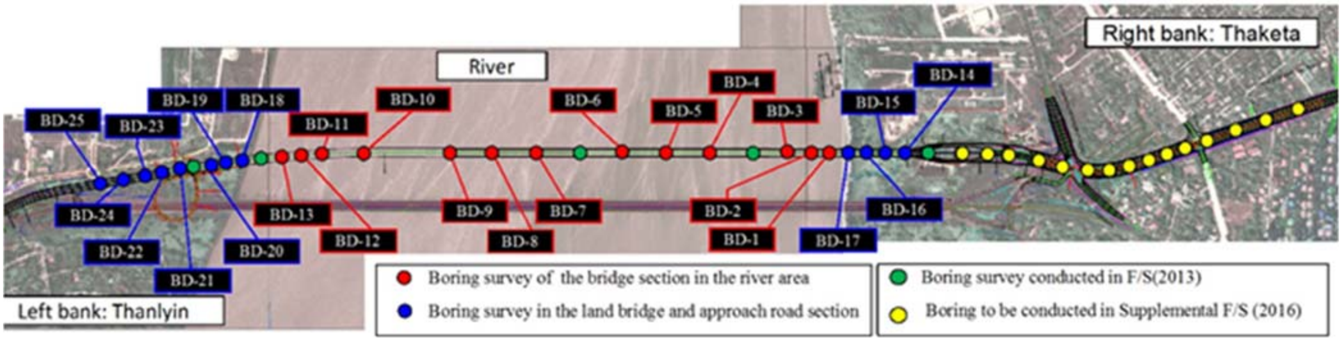
(2) Survey Scope

Soil survey is divided into six subcomponents: Mobilization and demobilization, Borehole drilling on land and in the river, Standard Penetration Test (SPT), Pressure meter Test, Laboratory test, and Reporting.

(3) Project Location (Locations of the Boring Survey)

The soil investigation survey was conducted from the Thanlyin side of the left bank to the Thaketa side of the right bank of the Project. In this survey, the JICA Survey Team used the soil investigation results of not only the feasibility study (F/S) survey in 2013 but also the supplemental F/S survey for the flyover section at Thaketa side which was conducted in September 2016.

The locations of where the survey was conducted are shown in Figure 2.1.1.



Source: JICA Study Team

Figure 2.1.1 Locations of Boring Survey

2.1.2 Summary of Results of Soil Investigation

(1) Summary of Soil Survey Results

1) Ground Conditions and Bearing Layer

Based on the survey results, 20 different soil layers including the flyover section were recognized in the design section of this area. For each section, 11 soil layers in the Thanlyin section, 14 soil layers in the river section, 7 soil layers in the Taketa section, and 10 soil layers in the flyover section have been confirmed, as shown in Table 2.1.1.

In the survey area, river sediments are distributed along the Bago River. The soil constitution is greatly changed in the alluvium distributed under this river sediment.

Cohesive soil dominates from the left bank of Thanlyin side to the right bank side of the Bago River, and is characterized by sandy soil prominent from the right bank side of the river section to the right bank of Thaketa side. The sedimentary relationship of cohesive soil and sandy soil of alluvium is considered to be largely interfinger relationship at this stage.

As the proposed bridge is designed with heavy and dynamic load and large spans, the pier foundation is designed generally as pile foundation according to soil conditions at site.

According to the survey results, the soil layers with N values of 50 or more correspond roughly to the distribution range of the Clayey SAND - II layer of the surveyed area and the CLAY - IV layer of the flyover area.

As bearing layer for the design of this project, we propose the following values according to JSHB (Substructure Edition, Japan Road Association, 2012, pp.278-279). Figures 2.1.2 to 2.1.4 show the soil profiles including the bearing layer line.

<Bearing Layer>

Sand Layer: N value of 30 or more (Clayey SAND-II)

Cohesive Soil Layer: N value of 20 or more (CLAY-AIV, CLAY-III, CLAY-IV)

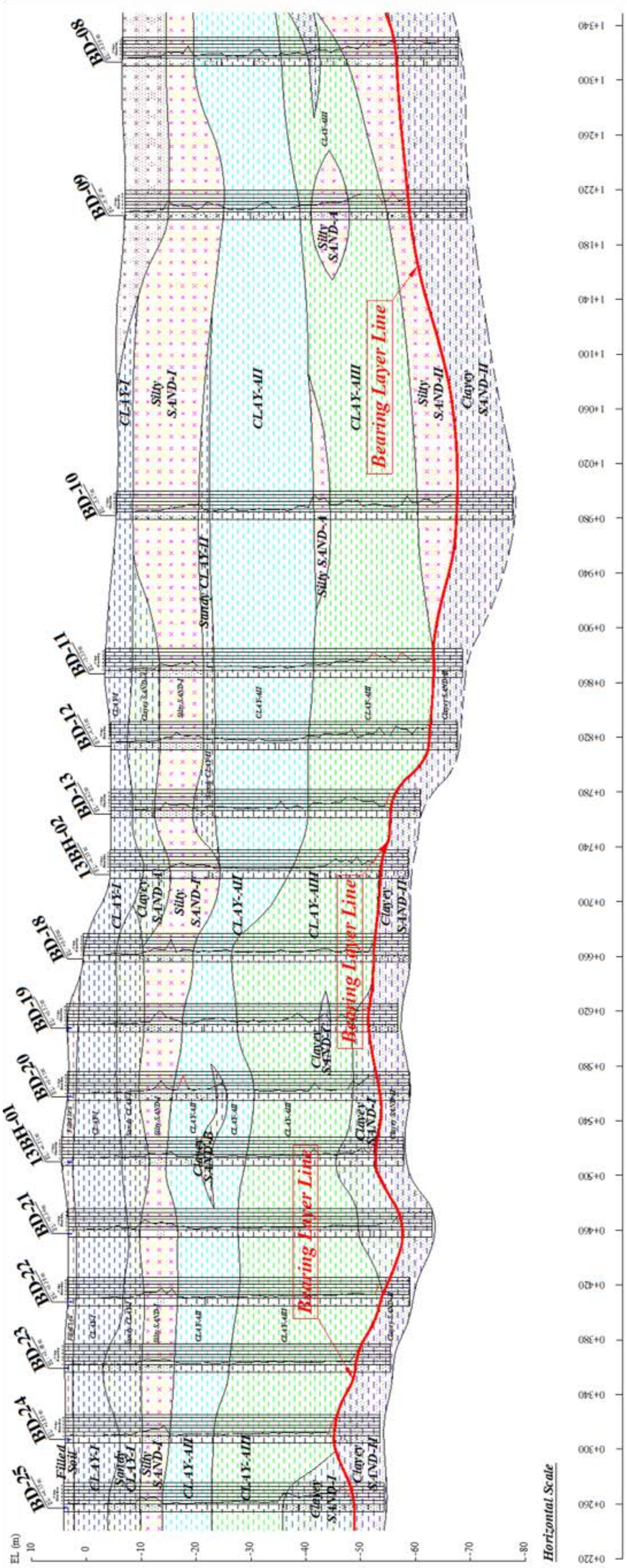
In addition, Clayey SAND – I distributed from the right bank of the river bed to the Taketa area was evaluated as a provisional bearing layer, since N values of 30 or more were continuously confirmed.

As the foundation surface for earthquake-resistant design, N value of 25 or more in the cohesive soil layer is required and N value of 50 or more in the sandy soil layer, so the bearing line shown in Figure 2.1.2~ Figure 2.1.4 roughly coincides with the foundation surface line. (“JSHB” - Earthquake Resistant Edition, Japan Road Association, 2012, p.33)

Table 2.1.1 Different Soil Layers of Each Section

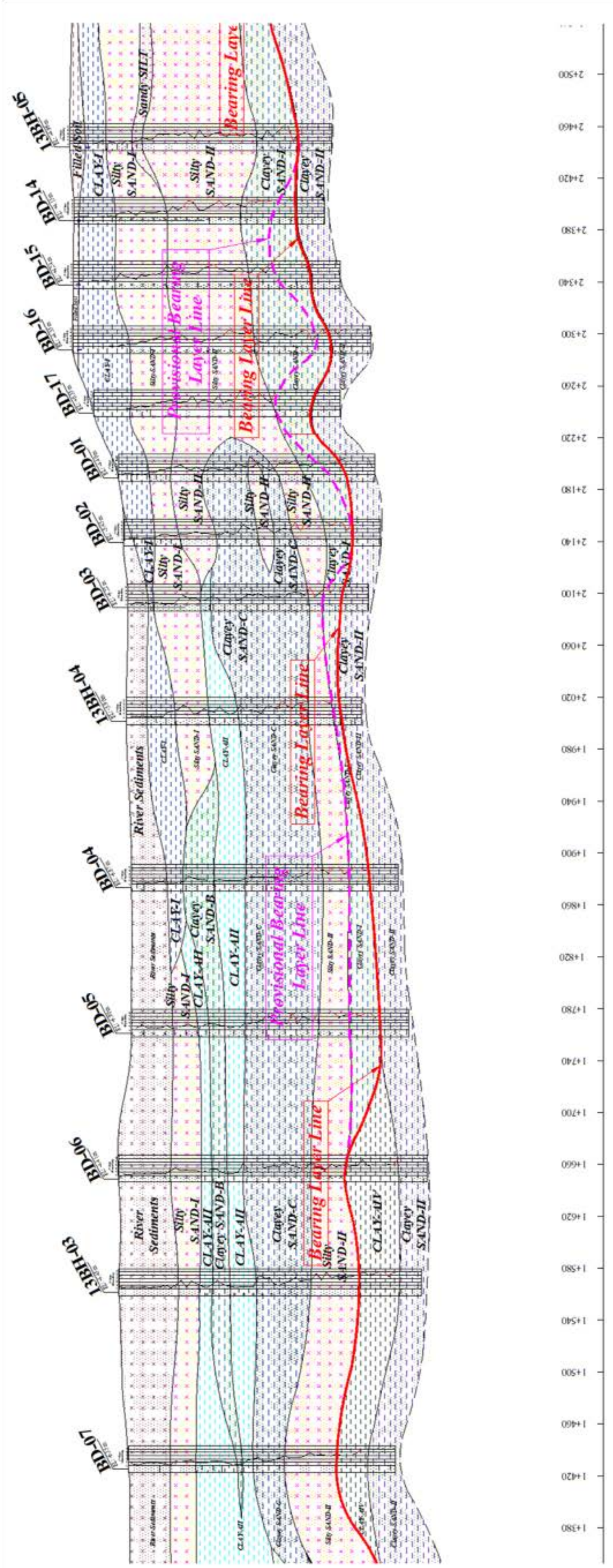
Formation	Section (Soil name for each section)			
	Thanlyin	River	Thaketa	Flyover(Thaketa)
	BD-25～(13)BH-2	(13)BH-2～BD-17	BD-17～(13)BH-5	(13)BH-5～(16) BH-1
Alluvium		Silty SAND- River Sediments		
	Filled Soil		Filled Soil	Filled Soil
	CLAY-I	CLAY-I	CLAY-I	CLAY-I
	Sandy CLAY-I			
	Clayey SAND-A	Clayey SAND-A		
	Silty SAND-I	Silty SAND-I	Silty SAND-I	Silty SAND-I
			Sandy SILT	Sandy SILT
		Sandy CLAY-II		
	CLAY-AII	CLAY-AII		
	Clayey SAND-B	Clayey SAND-B		
		Silty SAND-A		
	CLAY-AIII	CLAY-AIII		
	Clayey SAND-C	Clayey SAND-C		
		Silty SAND-II	Silty SAND-II	Silty SAND-II
				CLAY-II
Irrawaddy Formation	Clayey SAND-I	Clayey SAND-I	Clayey SAND-I	Clayey SAND-I
		CLAY-AIV		
				CLAY-III
	Clayey SAND-II	Clayey SAND-II	Clayey SAND-II	Clayey SAND-II
				CLAY-IV

Source: JICA Study Team



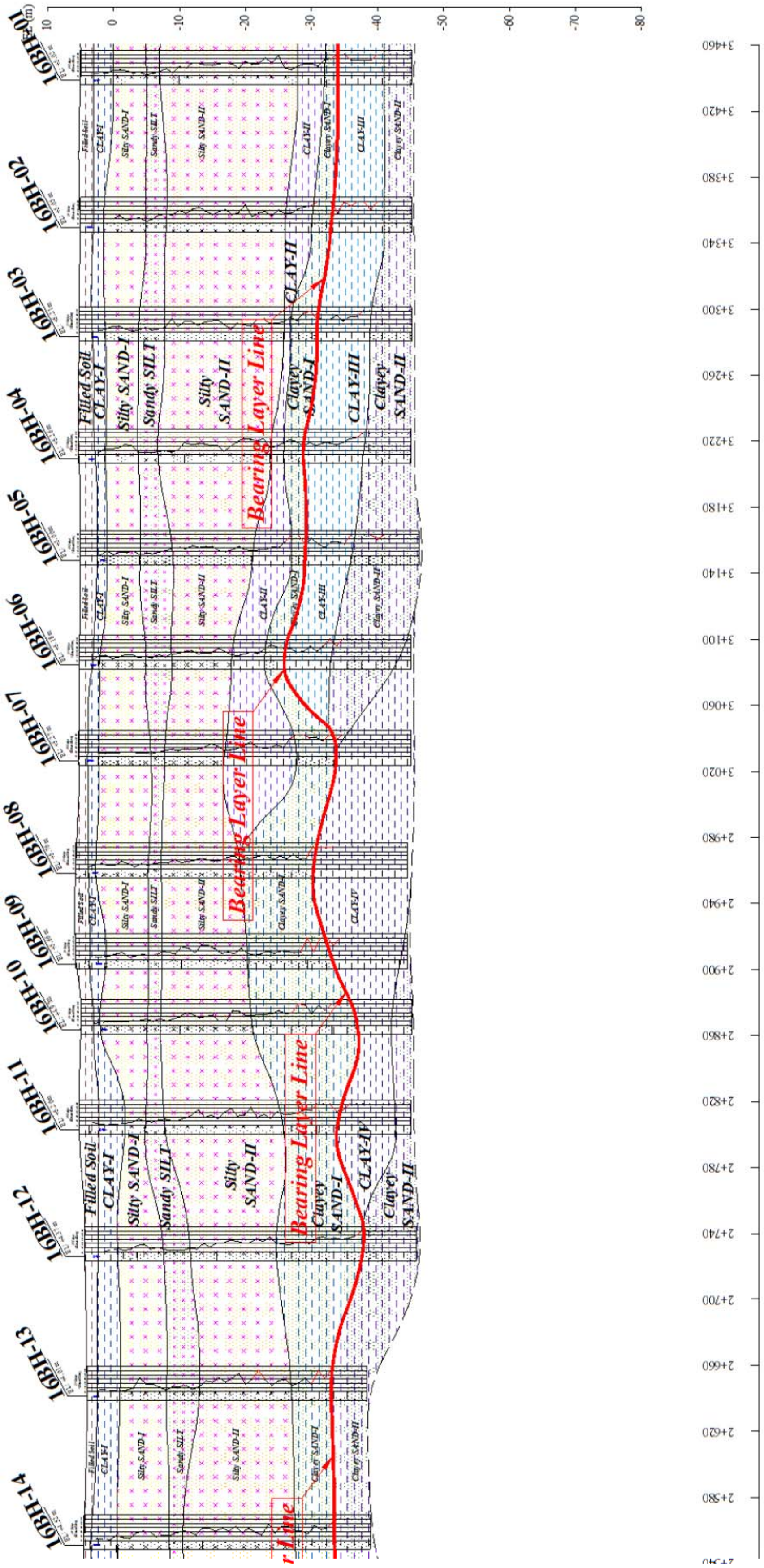
Source: JICA Study Team

Figure 2.1.2 Soil Profile with Bearing Layer (1/3)



Source: JICA Study Team

Figure 2.1.3 Soil Profile with Bearing Layer (2/3)



Source: JICA Study Team

Figure 2.1.4 Soil Profile with Bearing Layer (3/3)

2.1.2.2 Geotechnical Design Parameters

The following shows the geotechnical design parameters proposed by the soil survey.

(1) Left bank, Thanlyin side (from BD-25 to BH-2 of 2013 report)

Table 2.1.2 shows the proposed geotechnical design parameters for Thanlyin side.

Table 2.1.2 Proposed Geotechnical Design Parameters for Thanlyin Side

No.	Soil Name	Representative N Value	Unit Weight			Internal Friction Angle	Cohesive Strength	Deformation Modulus
			γt (kN/m^3)	γsat (kN/m^3)	γ' (kN/m^3)	φ (°)	c (kN/m^2)	E50 (kN/m^2)
1	Filled Soil	1 1)	18.0 2)	18.0	8.0	-	6 3)	700 3)
2	CLAY-I	1 1)	17.5 1)	17.5	7.5	-	15 1)	900 1)
3	Sandy CLAY-I	3 1)	17.5 1)	17.5	7.5	-	15 1)	2000 1)
4	Silty SAND-I	15 1)	16.5 1)	17.5	7.5	33 3)	-	6000 3)
5	Clayey SAND-A	3 1)	17.0 2)	18.0	8.0	28 3)	-	1200 3)
6	CLAY-AII	5 1)	17.5 1)	17.5	7.5	-	30 1)	3200 1)
7	Clayey SAND-B	17 1)	17.0 2)	18.0	8.0	33 3)	-	11900 3)
8	CLAY-AIII	7 1)	17.6 1)	17.6	7.6	-	42 3)	4900 1)
9	Clayey SAND-C	20 1)	17.0 2)	18.0	8.0	32 3)	-	14000 3)
10	Clayey SAND-I	23 1)	17.0 2)	18.0	8.0	31 3)	-	16100 3)
11	Clayey SAND-II	50 1)	19.0 2)	20.0	10.0	35 3)	-	35000 3)

1) These values were set up by field test or soil laboratory test result.
2) These values were set up by the reference value shown in NEXCO.
3) These values were set up by formula of SPTN-value.
4) These values were set up by formula.

Source: JICA Study Team

(2) River section, (from BH-2 of 2013 report to BD-17)

Table 2.1.3 shows the proposed geotechnical design parameters for River section.

Table 2.1.3 Proposed Geotechnical Design Parameters for River Section

No.	Soil Name	Representative N Value	Unit Weight			Internal Friction Angle	Cohesive Strength	Deformation Modulus
			γt (kN/m^3)	γsat (kN/m^3)	γ' (kN/m^3)	φ (°)	c (kN/m^2)	E_{50} (kN/m^2)
1	Silty SAND-River Sediments	3 1)	17.0 2)	18.0	8.0	29 3)	-	1200 1)
2	CLAY-I	1 1)	17.5 1)	17.5	7.5	-	10 1)	900 1)
3	Clayey SAND-A	3 1)	17.5 1)	18.5	8.5	28 3)	-	1200 3)
4	Silty SAND-I	13 1)	17.0 2)	18.0	8.0	33 3)	-	5200 3)
5	Sandy CLAY-II	9 1)	17.5 Same values as CLAY-AII	17.5	7.5	-	54 3)	6300 3)
6	CLAY-AII	7 1)	17.5 1)	17.5	7.5	-	42 3)	4900 3)
7	Clayey SAND-B	13 1)	17.0 2)	18.0	8.0	32 3)	-	9100 3)
8	Silty SAND-A	25 1)	17.0 2)	18.0	8.0	33 3)	-	17500 3)
9	CLAY-AIII	18 1)	18.0 2)	18.0	8.0	-	108 3)	12600 3)
10	Clayey SAND-C	20 1)	17.0 2)	18.0	8.0	33 3)	-	14000 3)
11	SiltySAND-II	30 1)	17.0 2)	18.0	8.0	34 3)	-	21000 3)
12	Clayey SAND-I	35 1)	19.0 2)	20.0	10.0	34 3)	-	24500 3)
13	CLAY-AIV	30 1)	18.0 2)	18.0	8.0	-	180 3)	21000 3)
14	ClayeySAND-II	50 1)	19.0 2)	20.0	10.0	35 3)	-	35000 3)

1) These values were set up by field test or soil laboratory test result.
2) These values were set up by the reference value shown in NEXCO.
3) These values were set up by formula of SPTN-value.
4) These values were set up by formula.

Source: JICA Study Team

(3) Right bank, Thaketa side (from BD-17 to BH-5 of 2013 report)

Table 2.1.4 shows the proposed geotechnical design parameters for Thaketa aide.

Table 2.1.4 Proposed Geotechnical Design Parameters for Thaketa Side

No.	Soil Name	Representative N Value	Unit Weight			Internal Friction Angle	Cohesive Strength	Deformation Modulus
			γt (kN/m^3)	γsat (kN/m^3)	γ' (kN/m^3)	φ (°)	c (kN/m^2)	E_{50} (kN/m^2)
1	Filled Soil	3 1)	19.0 2)	20.0	10.0	-	18 3)	2100 3)
2	CLAY-I	1 1)	17.5 1)	17.5	7.5	-	15 1)	900 1)
3	Silty SAND-I	13 1)	17.0 2)	18.0	8.0	32 3)	-	6500 3)
4	Sandy SILT	7 1)	17.0 2)	17.0	7.0	-	42 3)	4900 3)
5	Silty SAND-II	25 1)	17.0 2)	18.0	8.0	34 3)	-	17500 3)
6	Clayey SAND-I	35 1)	19.0 2)	20.0	10.0	34 3)	-	24500 3)
7	Clayey SAND-II	50 1)	19.0 2)	20.0	10.0	35 3)	-	35000 3)

1) These values were set up by field test or soil laboratory test result.
2) These values were set up by the reference value shown in NEXCO.
3) These values were set up by formula of SPTN-value.
4) These values were set up by formula.

Source: JICA Study Team

(4) Flyover section, Thaketa side (from BH-5 of 2013 report to BH-1 of 2016 report of the supplemental F/S report)

Table 2.1.5 shows the proposed geotechnical design parameters for the flyover section.

Table 2.1.5 Proposed Geotechnical Design Parameters for Flyover Section

No.	Soil Name	Representative N Value	Unit Weight			Internal Friction Angle	Cohesive Strength	Deformation Modulus
			γt (kN/m^3)	γsat (kN/m^3)	γ' (kN/m^3)	φ (°)	c (kN/m^2)	E50 (kN/m^2)
1	Filled Soil	4 5)	18.0 2)	18.0	8.0	-	25 5)	1000 5)
2	CLAY-I	4 1)	18.0 1)	18.0	8.0	-	25 1)	1000 1)
3	Silty SAND-I	10 1)	18.0 1)	19.0	9.0	32 3)	-	5000 3)
4	Sandy SILT	7 1)	17.0 2)	17.0	7.0	-	42 3)	4900 3)
5	Silty SAND-II	22 1)	17.0 2)	18.0	8.0	33 3)	-	15400 3)
6	CLAY-II	20 1)	18.0 2)	18.0	8.0	-	120 3)	14000 3)
7	Clayey SAND-I	35 1)	19.0 2)	20.0	10.0	33 3)	-	24500 3)
8	CLAY-III	31 1)	18.0 2)	18.0	8.0	-	186 3)	21700 3)
9	Clayey SAND-II	50 1)	19.0 2)	20.0	10.0	37 3)	-	35000 3)
10	CLAY-IV	50 1)	18.0 2)	18.0	8.0	-	300 3)	35000 3)

1) These values were set up by field test or soil laboratory test result.
2) These values were set up by the reference value shown in NEXCO.
3) These values were set up by formula of SPTN-value.
4) These values were set up by formula.
5) Refer to CLAY-I.

Source: JICA Study Team

2.2 TOPOGRAPHIC SURVEY

2.2.1 Survey Scope and Purpose

The results of topographic survey are utilized for the detailed engineering designs as well as other surveys including geological survey, materials investigation, underground survey, and hydrological survey.

The work period for the survey works is from the middle of October to the middle of December 2016.

Work items and quantities for topographic survey are as follows:

Table 2.2.1 DD Work Items and Quantities

Work Items	Quantity	
	Plan	Result
1. Control Point Survey		
1-1 Primary Control Points (by using GPS)	5 points	10
1-2 Secondary Control Points (by using TS)	20	20
1-3 Primary Leveling Network (fourth order leveling)	28.71	43.60
1-4 Secondary Leveling Network（Technical leveling)	3.71 km	3.71 km
2. Route Survey for Road and Flyover Portion (L=2.17 km including 391 m long on-ramp in Thanlyin)		
Land Portion		
2-1 Center Line Survey (20 m intervals with principal points)	1.20 km	1.20 km
2-2 Longitudinal Survey	1.20 km	1.20 km
2-3 Cross-section Survey (50 m both sides from center line)	90	117
On-ramp		
2-4 Center Line Survey (20 m intervals with principal points)	0.64 km	0.64 km
2-5 Longitudinal Survey	0.64 km	0.64 km
2-6 Cross-section Survey (50 m both sides from center line)	41	41
Additional Work (Star City)		
2-7 Center Line Survey (20 m intervals with principal points)	0.60 km	0.60 km
2-8 Longitudinal Survey	0.60 km	0.60 km
2-9 Cross-section Survey (50 m both sides from center line)	32	32
2-10 Planimetric survey (50 m both sides from center line)	17.8ha	42.4 ha
3. Route Survey for Bridge Portion (L = 1.928 km)		
3-1 Longitudinal Survey	1.93 km	1.93 km
3-2 Cross-section Survey (50 m both sides from center line)	96	38
3-3 Planimetric Survey (50 m both sides from center line)	19.3 ha	12.1 ha

Source: JICA Study Team

On the other hand, work items and quantities, as specified in the F/S, are as follows:

2.2.2 Control Point Survey

Five primary control points as well as a supplementary control point in each were installed to average out in the survey area. The total number of primary control points is ten.

The secondary control point was measured based on the primary control point and placed at 20 points in the whole area.

2.2.3 Route Survey

The route survey (4.37 km) is comprised of the following:

- Main route：On-ramp 1.20 km, the bridge section at Bago River 1.93 km
- Access road to the main route：0.64 km
- Access road to Star City：0.60 km

All center line points were staked out by TS. In addition, cross-section survey and longitudinal profile survey were conducted.

The elevation of the center line points were surveyed by direct leveling. Some points located in a bush at the Thanlyin side, on the other hand, were surveyed by TS.

2.2.4 Advanced GPS Survey for Basic Design

For the D/D of the flyover section, six points of the road center on the existing road were surveyed by GPS at first so that the B/D can be commenced without waiting for the completion of the survey by TS.

2.2.5 Level of Girder Soffit of Existing Thanlyin Bridge

In order to clarify the clearance of the Thanlyin Bridge, leveling survey was conducted at six points. Survey works were conducted twice and the levels of the girder soffit were confirmed as shown in Table 2.2.2.

Table 2.2.2 Elevation of Thanlyin Bridge Girder Soffit

NO	FIRST			SECOND			
	EAST	NORTH	ELEVATION	EAST	NORTH	ELEVATION	Difference
1	205372.930	1857890.014	13.232	205368.877	1857897.094	13.225	0.007
2	205316.840	1857987.121	13.150	205316.873	1857987.106	13.198	-0.048
3	205260.784	1858084.086	13.174	205260.871	1858084.133	13.254	-0.080
4	205203.776	1858182.774	13.174	205203.862	1858182.793	13.259	-0.085
5	205147.730	1858279.760	13.152	205147.840	1858279.818	13.254	-0.102
6	205091.693	1858376.789	13.164	205091.760	1858376.830	13.209	-0.045
7	204708.346	1859040.738	11.338				
8	204749.172	1858970.059	11.659				

Source: JICA Study Team

Figure 2.2.1 shows the basic longitudinal section of Thanlyin Bridge. Heavy freight ships mainly pass near the left bank because the clearance gradually gets lower from the center span to the right bank.

Source: JICA Study Team

Figure 2.2.1 Basic Longitudinal Section of Thanlyin Bridge

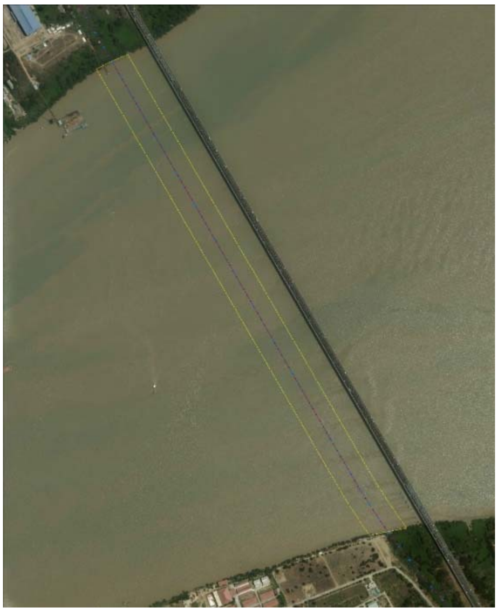
2.2.6 Topographic Survey

In the computer-aided design (CAD) data of topographic map made in the F/S, many initials are used for a layer name, and there were many things which were difficult to read and understand.

Layer name should be easy to know as much as possible. Layer name was newly provided in this topographic survey for the D/D.

2.2.7 Bathymetric Survey

Bathymetric survey was carried out along the main line in the river part (1.93 km) from the middle of November to the middle of December, using the technique of echo sounding system. On the other hand, the technique of real time kinematic (RTK) was employed for the surveys on land.



Source: JICA Study Team

Figure 2.2.2 Location of Bathymetric Survey

Table 2.2.3 Work Quantity of Bathymetric Survey

Work Item	Quantity
1. Route Survey for Bridge Portion (L = 1.928 km)	
1-1 Longitudinal Survey	1.93 km
1-2 Cross-section Survey (50m both sides from	96 sections
1-3 Planimetric Survey (50 m both sides from center	19.3 ha

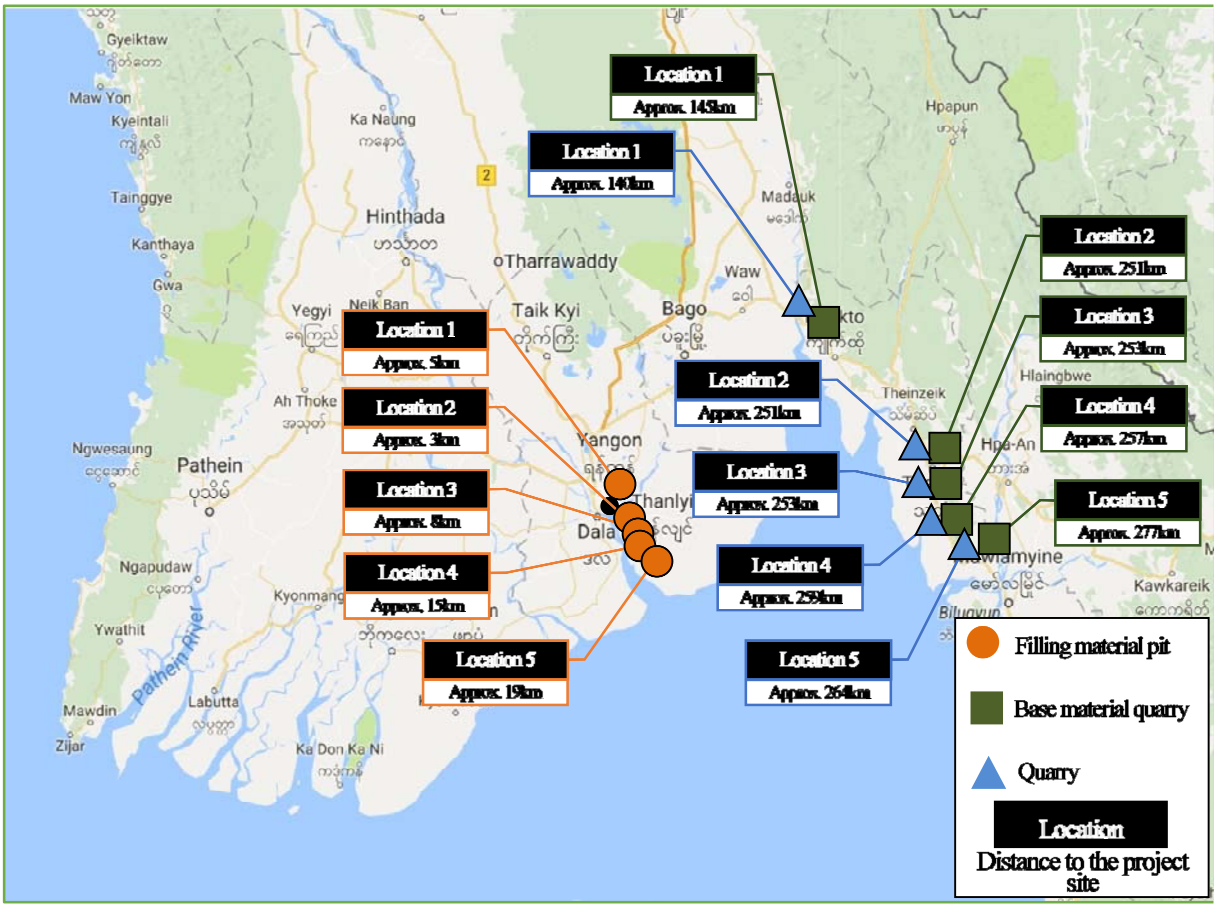
Source: JICA Study Team

2.3 MATERIAL SURVEY

2.3.1 Survey Scope and Purpose

Material survey will be conducted with pits and quarries for gravel and crushed stone to get information required for construction concerning matters related to transporting capacity such as route, method of transportation from points of material supply to the site, as well as price, quality, and supply capacity. The survey will also be conducted with the suppliers of the materials (e.g. reinforcing bars, steel materials, cement, asphalt, and building equipment). Table 2.3.1 shows the details of the material survey.

The locations of the material survey are shown in Figure 2.3.1.



Source: JICA Study Team

Figure 2.3.1 Locations of Material Survey

Table 2.3.1 Summary of Aggregate Test Results (Yinnyein Area)

2.3.2 Summary of Survey Results

2.3.2.1 Material Test for Filling

According to the laboratory test results, low plasticity to medium plasticity clay layer is well observed in Thaketa side. Moreover, design CBR value is eight in average.

In Thanlyin side, the percentage of sand is more than in the Thaketa side. Moreover, design CBR values are also less than for Thaketa side, although there are some parts that CBR value is more than eight.

2.3.2.2 Material Test for Filling

According to laboratory test results, Aung Win, Kyauk Tan location sample is more than other place in maximum dry density. The soil type is clayey sand. The seco nd maximum dry density is great motion Thanlyin location. The soil type of this location is fat clay.

The maximum dry density of Ko Toe, Thanlyin location is more than Marga, Thilawa sand location. Moreover, design CBR also is more than that location.

2.3.2.3 Material Test for Subgrade

According to the laboratory test results, all soils are sandy soil location. The maximum dry density of Paung and Zin Kyeik location is more than 2 t/m^3. The modified CBR results are more than 50 in average.

The maximum dry density of Thaton and Yinnyein location is also 1.9 t/m^3 in average. The average modified CBR values are also 40 in average.

2.3.2.4 Material Test for Aggregate

According to the laboratory test results, the main particle sizes for the Moke Paline area, Paung area, and Zin Kyeik area are from 25 mm to 38 mm. On the other hand, the main one for Yinnyein area and Thaton area is from 12.5 mm to 25 mm. Hence, aggregates from Yinnyein area and Thaton area are relatively small.

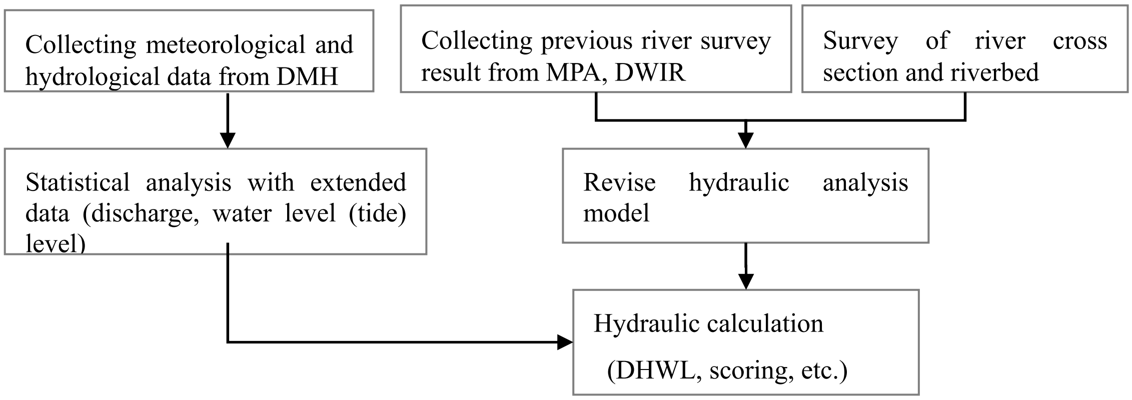
Abrasion rates for the Moke, Paung, and Zin Kyeik areas are less than 20%. Moreover, the one in Yinnyein area and Thaton area is less than 35%. According to JIS standard, every aggregate is suitable for road since Grade 1 of road aggregate is not more than 35%.

2.4 RIVER AND HYDROLOGICAL SURVEY

In order to design the new bridge, it is necessary to collect and correlate the basic meteorological and hydraulic data. In this section, hydrological and hydraulic analysis shall be carried out based on hydrological data collection and river section and bathymetric survey.

2.4.1 Outline of Hydrological Survey at D/D stage

Hydrological survey is composed of the hydrological data collection survey and river section survey. In the hydrological survey at D/D stage, the following items are conducted:



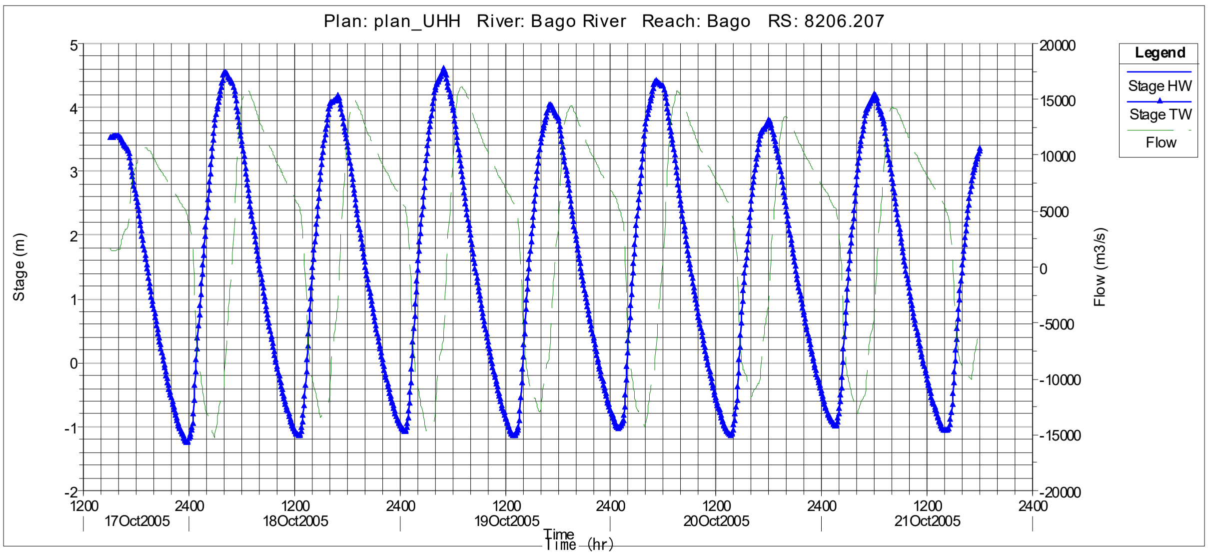
Source: JICA Study Team

Figure 2.4.1 Study Flow at D/D stage

2.4.2 Summary of Survey Results

2.4.2.1 Hydrological Data Collection Survey

From the results of low discharge during the dry season, the hydraulic calculation of high water level is calculated by using 0.015 for roughness coefficient. Hydraulic calculation results for 2 cases are shown in Table 2.4.1 and Figure 2.4.2.



Source: JICA Study Team

Figure 2.4.2 Tidally-dominated Water Level and Discharge Fluctuation at New Bago Bridge – Case 2

Table 2.4.1 Result of Hydraulic Analyses

Item	Unit	New Bago Bridge +8206.2	Remarks
< Hydraulic Calculation Results >		Case 1: Annual Minimum Tide and Flood	
High Water Level	m	3.07	at Low Discharge
Maximum Discharge	m^3/s	9,298.12	
Low Discharge	m^3/s	8.06	
Tidal flow	m^3/s	9,290.06	falling tide
Minimum Discharge	m^3/s	-14,428.05	
100 year Flood	m^3/s	8.06	
Tidal flow	m^3/s	-14,436.11	rising tide
< Hydraulic Calculation Results >		Case 2: Annual Maximum Tide and Flood	
High Water Level:	m	4.59	at 100-year Flood
Maximum Discharge	m^3/s	16,168.13	
100 year Flood	m^3/s	3,296.73	
Tidal flow	m^3/s	12,871.40	falling tide
Minimum Discharge	m^3/s	-15,230.83	
100 year Flood	m^3/s	3,296.73	
Tidal flow	m^3/s	-18,527.56	rising tide
< Probability Calculation >			
Probable H.W.L. (MPA based)	m	7.80	
Probable H.W.L. (Land Survey)	m	4.99	△2.814m
< Planned Value >			
Design Discharge	m^3/s	16,169	100-year flood
Design H.W.L.	m	4.99	

Source: JICA Study Team

2.4.2.2 Scouring Depth

The results of scour estimation from superposition of components are shown in Table 2.4.2.

Table 2.4.2 Result of Scouring Computation

Pier No.	Scour of components: Total Scour (m)	Scoru for Pier (m)	Scoru for Pile cap (m)	Contraction Scour (m)	Riverbed Elevation (MSL+m)	Water Depth (m)	Mean Velocity (m/s)	Pile top Elevation (MSL+m)	Scoured Level (MSL+m)
P1	0.35	0.35	-	0.00	4.30	0.29	0.02	3.55	3.95
P2	0.36	0.36	-	0.00	4.30	0.29	0.02	3.49	3.94
P3	0.37	0.37	-	0.00	4.30	0.29	0.02	3.44	3.93
P4	0.20	0.20	-	0.00	4.30	0.29	0.02	3.49	4.10
P5	0.32	0.32	-	0.00	4.30	0.29	0.02	3.51	3.98
P6	3.86	3.15	0.36	0.35	-1.72	6.31	0.78	-3.45	-5.58
P7	2.34	1.01	0.99	0.35	-5.35	9.94	0.78	-3.45	-7.69
P10	6.72	5.80	0.58	0.35	-4.55	9.14	0.88	-9.20	-11.27
P11	6.72	5.53	0.84	0.35	-5.41	10.00	1.00	-9.20	-12.13
P12	5.71	4.25	1.11	0.35	-7.96	12.55	1.06	-9.20	-13.67
P13	5.46	4.14	0.97	0.35	-8.02	12.61	1.01	-9.20	-13.48
P14	5.14	4.03	0.76	0.35	-6.28	10.87	1.01	-8.06	-11.42
P15	5.74	4.73	0.66	0.35	-5.09	9.68	0.89	-8.06	-10.83
P16	5.08	4.11	0.63	0.35	-5.26	9.85	0.92	-8.06	-10.35
P17	2.99	2.28	0.36	0.35	-6.70	11.29	0.92	-8.06	-9.69
P18	3.00	2.12	0.53	0.35	-6.99	11.58	0.98	-8.06	-9.99
P19	2.89	2.09	0.45	0.35	-6.88	11.47	0.97	-8.06	-9.77
P20	2.97	2.00	0.62	0.35	-6.55	11.14	0.97	-7.28	-9.52
P21	2.40	1.71	0.34	0.35	-6.15	10.74	0.79	-7.55	-8.55
P22	2.86	2.51	-	0.35	-4.61	9.20	0.79	-7.59	-7.47
P23	2.01	1.66	-	0.35	-0.05	4.64	0.79	-2.39	-2.06
P24	0.13	0.13	-	0.00	4.11	0.48	0.01	3.73	3.98
P25	0.13	0.13	-	0.00	4.04	0.55	0.01	3.78	3.92

Source: JICA Study Team

2.5 PUBLIC UTILITIES SURVEY

2.5.1 Survey Scope and Purpose

Public utilities survey was conducted in order to get the information for all public utilities in the project area. The survey is comprised of underground utilities survey and aboveground utilities survey.

(1) Underground Utilities Survey

Test pit excavation was carried out in order to identify the location, type, and size of all underground utilities in the project area.

(2) Aboveground Utilities Survey

Aboveground utilities survey was carried out in order to identify the location, type, size, and material of all aboveground utilities in the project area.

In addition to public utilities such as electric pole, telecommunication pole, lighting, and private facilities such as advertisement, drinking water post were also surveyed.

2.5.2 Existing Utilities Layout

(1) Existing Underground Utilities Layout

The existing underground utilities layout is shown in Figure 2.5.1.

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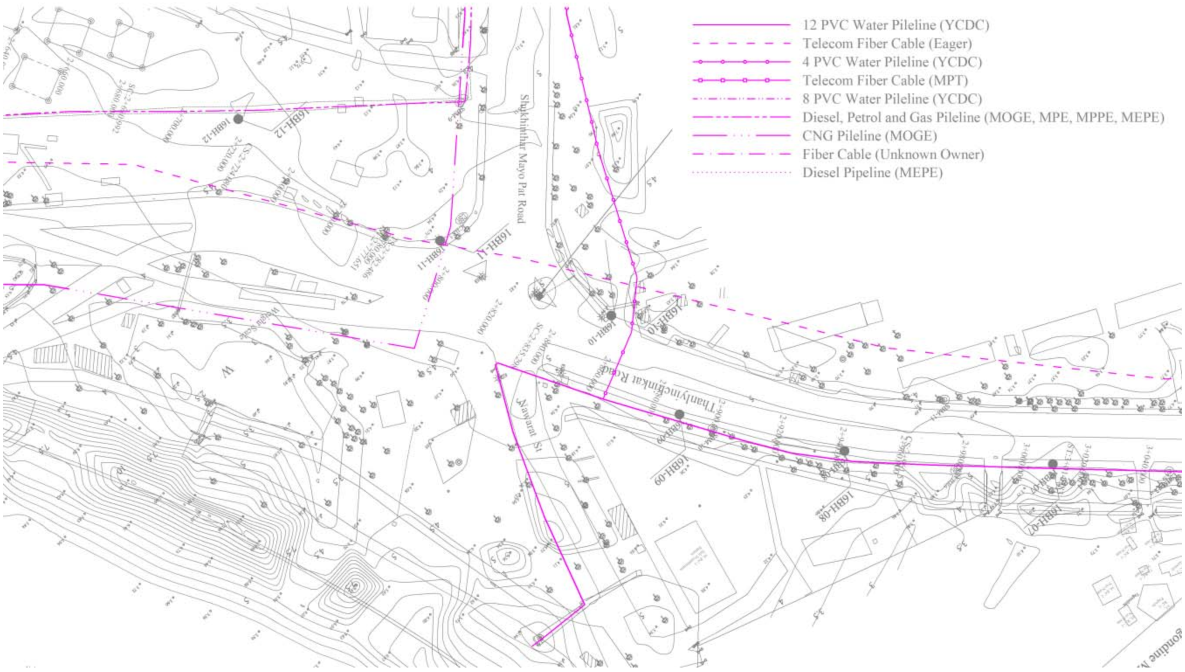
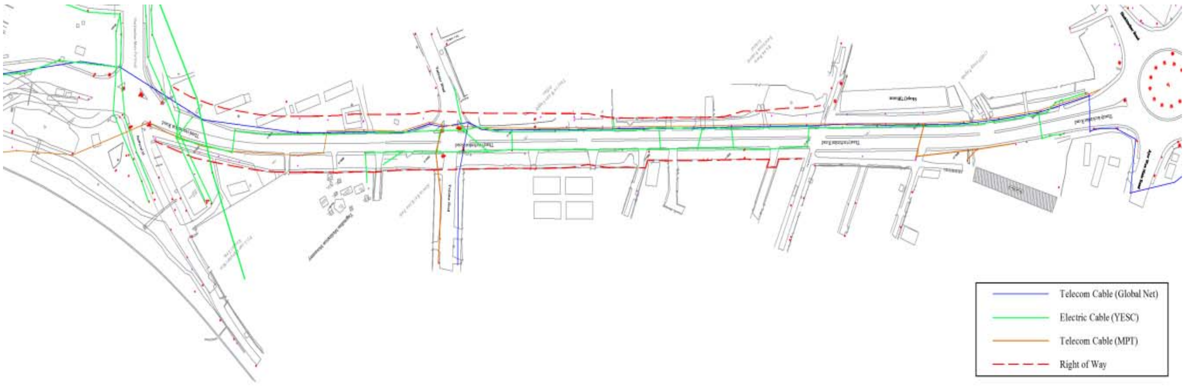


Source: JICA Study Team

Figure 2.5.1 Existing Underground Utilities Layout

(2) Existing Aboveground Utilities Layout

The existing aboveground utilities layout is shown in Figure 2.5.2.



Source: JICA Study Team

Figure 2.5.2 Existing Aboveground Utilities Layout

CHAPTER 3. ROAD DESIGN

3.1 GEOMETRIC DESIGN

3.1.1 Design Standard

The Bago River Bridge was classified as a Main Arterial Road in Urban Area with 60 km/h design speed. Table 3.1.1 shows the design standards for the project road and the applied value in the design.

Table 3.1.1 Geometric Design Standards Applied to the Project

Design Element	Design Standard	Design Value in the Project
Design Speed	60 km/h	60 km/h
Radius of Curve Desirable Minimum Minimum Absolute Minimum	 200 m 150 m 120 m	320 m
Minimum Curve Length Desirable Minimum	 700/θ* m 100 m	150.231 m
Minimum Length of Transition Curve	50 m	51.200 m
Minimum Radius to Omit Transition Curve Desirable Minimum	 1,000 m 500 m	2,000 m
Maximum Grade Desirable Absolute Maximum	 5% 7%	3.000%
Minimum Vertical Curve Radius Crest Desirable Absolute Minimum Sag Desirable Absolute Minimum	 2,000 m (K=20) 1,400 m (K=14) 1,500 m (K=15) 1,000 m (K=10)	4,400 m 1,900 m
Minimum Length of Vertical Curve	50 m	50 m
Normal Cross Slope	2.0%	2.0%
Superelevation Radius of Curve 120 ≤ R < 150 150 ≤ R < 190 190 ≤ R < 230 230 ≤ R < 270 270 ≤ R < 330 330 ≤ R < 420 420 ≤ R < 560 560 ≤ R < 800 800 ≤ R < 2000	 10% 9% 8% 7% 6% 5% 4% 3% 2%	
Minimum Radius of Curve without Superelevation	2,000 m	2,000 m
Maximum Compound Grade	10.5%	6.2%
Minimum Sight Distance Stopping Sight Distance Passing Sight Distance for Dual 1-lane Road Only Desirable Minimum	 75 m 350 m 250 m	 94.008 m not applicable
Vertical Clearance	5.000 m	5.000 m/5.500 m

Source: ASEAN Highway Standards and Japanese Road Structure Ordinance
*Remark *: θ is an intersecting angle. When θ is less than 2°, θ is applied as 2°.*

The Project was planned to have approach roads from the Star City Area to the project road, and between the intersection of Shukhinthar Mayopat Road with Thanlyin Chin Kat Road and the toll plaza of the project road. These approach roads were designed applying the design standards for ramps. Table 3.1.2 shows the design standards and the design value in the Project.

Table 3.1.2 Geometric Design Standards of Ramps

Design Element	Design Standard	Design Value in the Project
Ramp Design Speed	30 km/h	30 km/h
Radius of Curve Desirable Minimum Absolute Minimum	 30 m 20 m	 58 m
Minimum Parameter of Transition Curve	20 m	50 m
Minimum Radius to Omit Transition Curve	140 m	140 m
Maximum Grade Desirable Absolute Maximum	 9.0% 10.0%	 5.479%
Vertical Curve Minimum Vertical Curve Radius Crest Sag Minimum Vertical Curve Length	 250 m 250 m 25 m	 1000 m 1200 m 30 m
Normal Cross Slope	2.0%	2.0%
Superelevation Radius of Curve R < 50 50 ≤ R < 70 70 ≤ R < 90 90 ≤ R < 130 130 ≤ R < 160 160 ≤ R < 210 210 ≤ R < 280 280 ≤ R < 400 400 ≤ R < 800	 10% 9% 8% 7% 6% 5% 4% 3% 2%	
Maximum Combined Grade	12.0%	10.537%
Minimum Stopping Sight Distance	30 m	41.689 m

Source: Japanese Road Structure Ordinance

The design of the entry point of the approach road from the Star City Area into the Bago Bridge through lanes (on-ramp) was carried out referring to the design standards for ramp terminal. Table 3.1.3 gives the design standards and design value in the Project.

Table 3.1.3 Geometric Design Standards of Ramp Terminals

Design Element	Design Standard	Design Value in the Project
Through Lanes' Design Speed	60 km/h	60 km/h
Off-ramp Minimum Radius of Curve at the Nose Section Parameter of transition curve at the nose section Desirable Minimum	 100 m 50 m	 not applicable not applicable

Design Element	Design Standard	Design Value in the Project
Absolute Minimum	40 m	
Vertical Curve of Ramps near Nose Section Vertical Curve Radius Crest Curve Sag Curve	 450 m 450 m	 1,800 m -
Length of Speed-Change Lane Deceleration Lane Standard Length of Deceleration Lane /1 Standard Length of Taper /2 Divergence Angle /3 Acceleration Lane Standard Length of Acceleration Lane /1 Standard Length of Taper /2	 70 m 45 m 1/15 ~ 1/20 120 m 45 m	 not applicable 144 m (150 m) 54 m (104 m)

Adjustment Factor for Speed-Change Lane Length by the Through Lane's Vertical Grade				
Average Grade of Through Lane (%)	0 < i ≤ 2	2 < i ≤ 3	3 < i ≤ 4	4 < i
Factor for Descending Deceleration Lane	1.00	1.10	1.20	1.30
Factor for Ascending Acceleration Lane	1.00	1.20	1.30	1.40

Source: Japanese Road Structure Ordinance

Remark /1: excluding taper

/2: for parallel type speed-change lane design

/3: for tapered type speed-change lane design

As the acceleration lane and taper of the approach road from the Star City Area to the Bago River Bridge are located in the +2.5% vertical alignment section, the adjustment factor of 1.20 shall be applied to the ascending acceleration lane and taper lengths. Thus the required lengths are calculated as follows:

Adjusted acceleration length= 120×1.2 = 144 m

Adjusted taper length = 45×1.2 = 54 m

3.1.2 Typical Cross Section

The project road was designed as a dual two-lane highway with 3.50 m wide carriageways, except for the flyover section above Thanlyin Chin Kat Road where the project road is a dual one-lane highway.

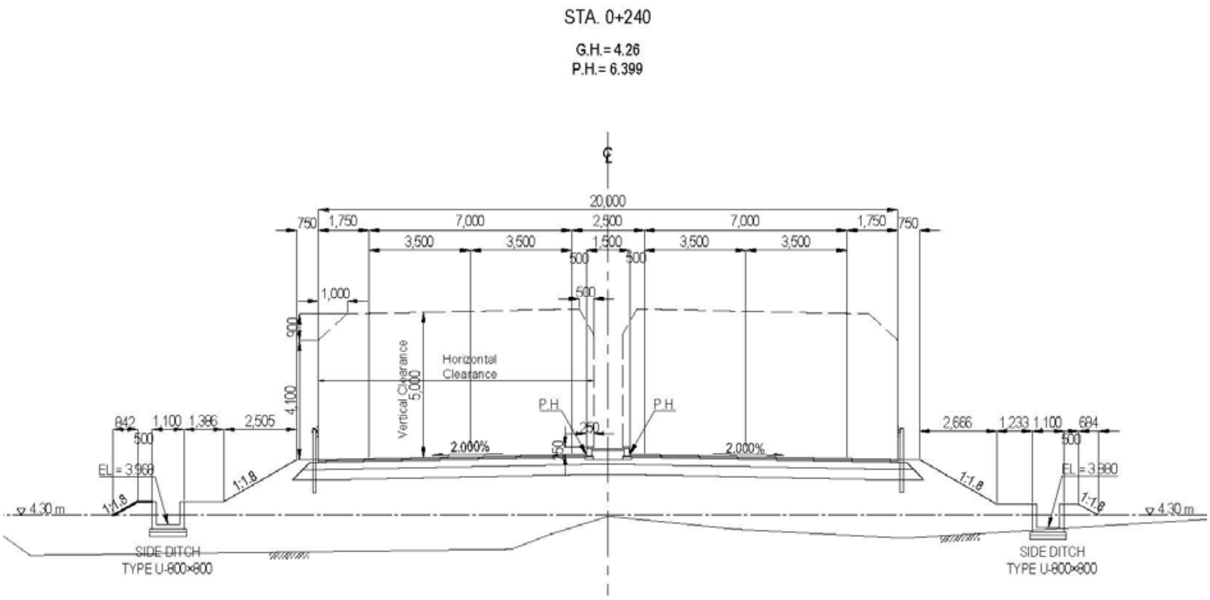
The cross section elements of the project road consist of median, inner shoulder, carriageways, and outer shoulder. Due to the design conditions of the bridge/flyover, the median width has some variations.

Table 3.1.4 Cross Section Elements of the Project Road

Cross Section Element	Width
Median Flyover Section	 0.750 m
Earthwork Section, and Steel Box Girder Bridge/PC Precast Box Girder Bridge Section	1.500 m
Steel Cable Stayed Bridge Section	3.700 m
Inner Shoulder	0.500 m
Two-lane Carriageway	2@3.5000 = 7.000 m
Outer Shoulder Earthwork Section in Package 1 Other Sections	 1.750 m 1.500 m

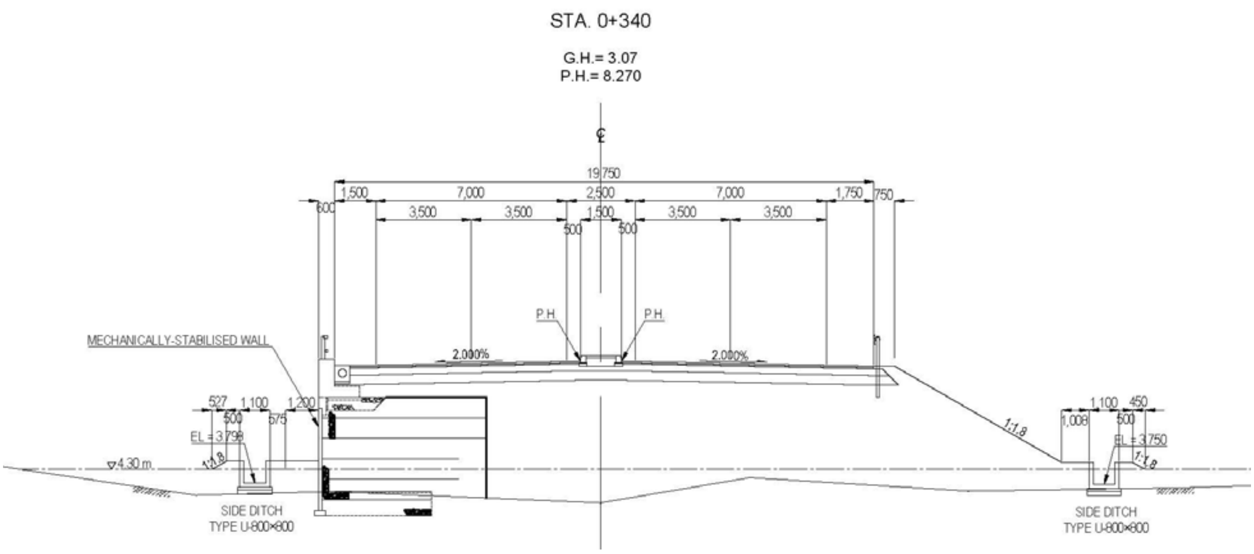
Source: JICA Study Team

Figure 3.1.1 to Figure 3.1.3 show the applied typical cross sections in the Project.



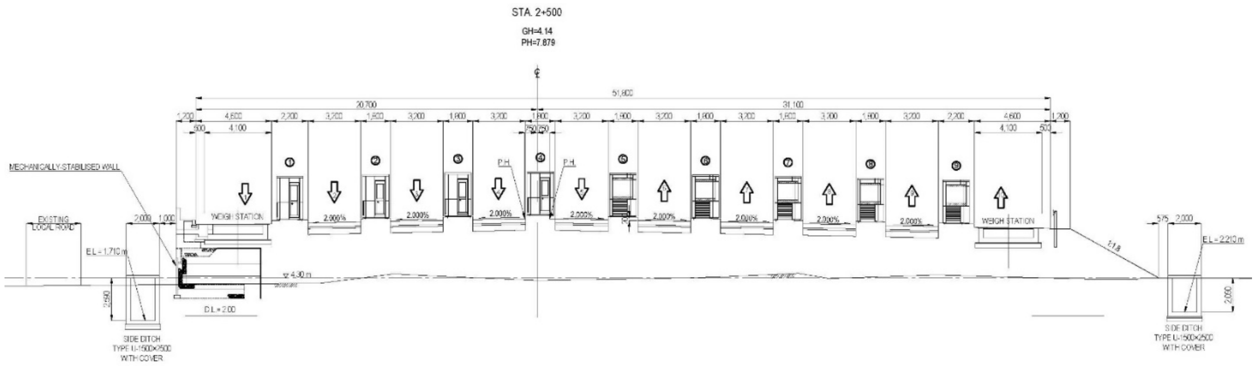
Source: JICA Study Team

Figure 3.1.1 Typical Cross Section of Earthwork Section in Package 1



Source: JICA Study Team

Figure 3.1.2 Typical Cross Section of Earthwork Section in Package 1 with Mechanically-stabilized Wall at the Left Side



Source: JICA Study Team

Figure 3.1.3 Typical Cross Section of Toll Plaza Area in Package 2 with Mechanically-stabilized Wall at the Left Side

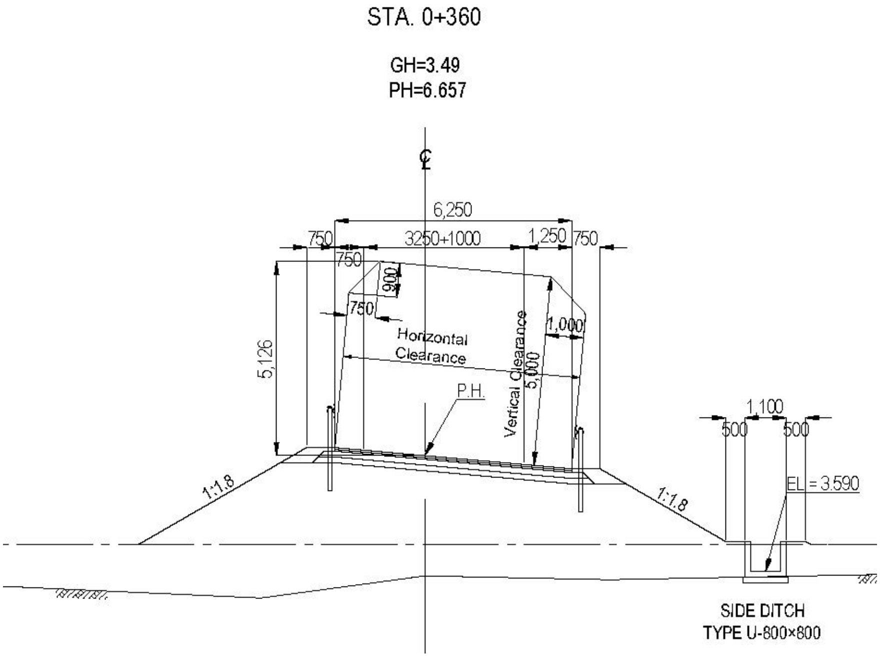
The approach road from the Star City Area to the project road was designed as one-lane ramp with cross section elements given in Table 3.1.3 .

Table 3.1.5 Cross Section Elements of the Ramp from the Star City Area

Cross Section Element	Width
Inner Shoulder	0.750 m
One-lane Carriageway	3.250 m
Outer Shoulder	1.250 m

Source: JICA Study Team

Figure 3.1.4 shows the typical cross section of the approach road in the circular curve (R = 58.0 m) section. In accordance with the design standards, the radius of R = 58.0 m requires widening of 1.0 m and superelevation of 9.0%. The height of 5.126 m from P.H. (proposed height) represents the required vertical clearance of 5.0 m in the 9.0% superelevation section.



Source: JICA Study Team

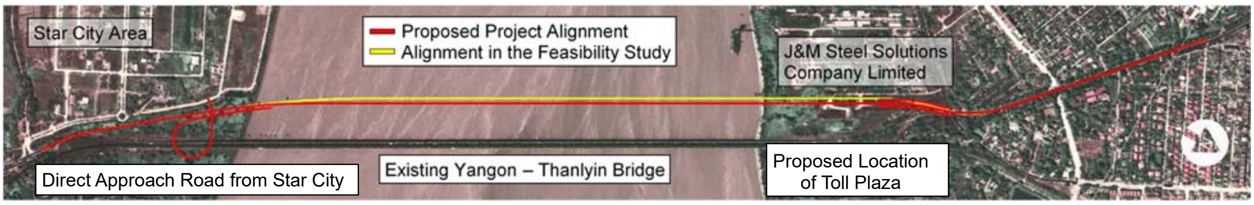
Figure 3.1.4 Typical Cross Section of Approach Road from the Star City Area

3.1.3 Road Alignment of Main Route

The Supplemental Survey for the Project for the Construction of Bago River Bridge (2016) amended the original project scope (2014) by adding the toll collection facilities (toll plaza) at the right bank side of Bago River and flyover section above Thanlyin Chin Kat Road.

Because of the introduction of the toll plaza which requires wider project land than the normal roadway section, the land acquisition of the J&M Steel Solutions Company Limited area will be required if the project alignment is not adjusted from the original plan proposed in the feasibility study.

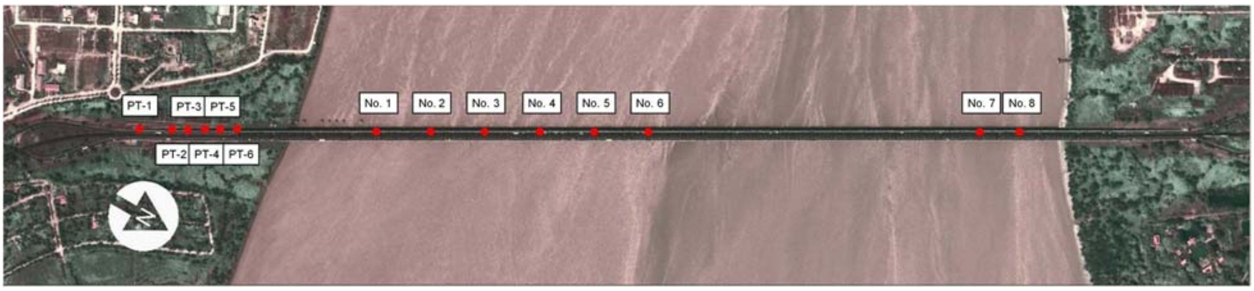
To minimize the required land acquisition in the J&M area, the centerline above the Bago River section was adjusted by shifting it 15 m upstream. With this adjustment, the J&M area and the local road along the J&M area will not be touched by the Project. Figure 3.1.5 shows the proposed alignment of the Project (red line) and the original alignment in the Feasibility Study (yellow line).



Source: JICA Study Team

Figure 3.1.5 Alignment of the Main Road

The navigation clearance on the Bago River is the important design control of the Project. The maintained navigation clearance under the existing Yangon – Thanlyin Bridge shall also be kept by the Bago Bridge. In order not to reduce the navigation clearance under the Bago Bridge, the soffit level of the existing Yangon – Thanlyin Bridge was surveyed. Figure 3.1.6 shows the survey locations and the surveyed existing soffit levels. It is noted that points No. 1 to No. 6 indicate the spans equipped with navigation signs on both sides. The proposed height of the Project (vertical alignment) was designed to maintain the surveyed height with around 50 cm allowance at the soffit level of Bago Bridge.



No.	1	2	3	4	5	6	7	8
Elevation	13.232	13.150	13.174	13.174	13.152	13.164	11.659	11.338
Easting	205372.930	205316.840	205260.784	205203.776	205147.730	205091.693	204749.172	204708.346
Northing	1857890.014	1857987.121	1858084.086	1858182.774	1858279.760	1858376.789	1858970.059	1859040.738

No.	PT-1	PT-2	PT-3	PT-4	PT-5	PT-6	
Elevation	7.594	9.781	10.711	11.431	12.680	13.150	
Easting	205612.913	205579.724	205564.310	205545.627	205529.867	205511.600	
Northing	1857463.330	1857521.737	1857551.111	1857580.640	1857607.410	1857638.140	

Source: JICA Study Team

Figure 3.1.6 Surveyed Location and Soffit Level of Existing Yangon - Thanlyin Bridge

Points PT-1 to PT-6 were surveyed to check the vertical clearance required for the loop-type approach road from the Star City Area to Bago River Bridge when the road crosses under the existing Yangon – Thanlyin Bridge.

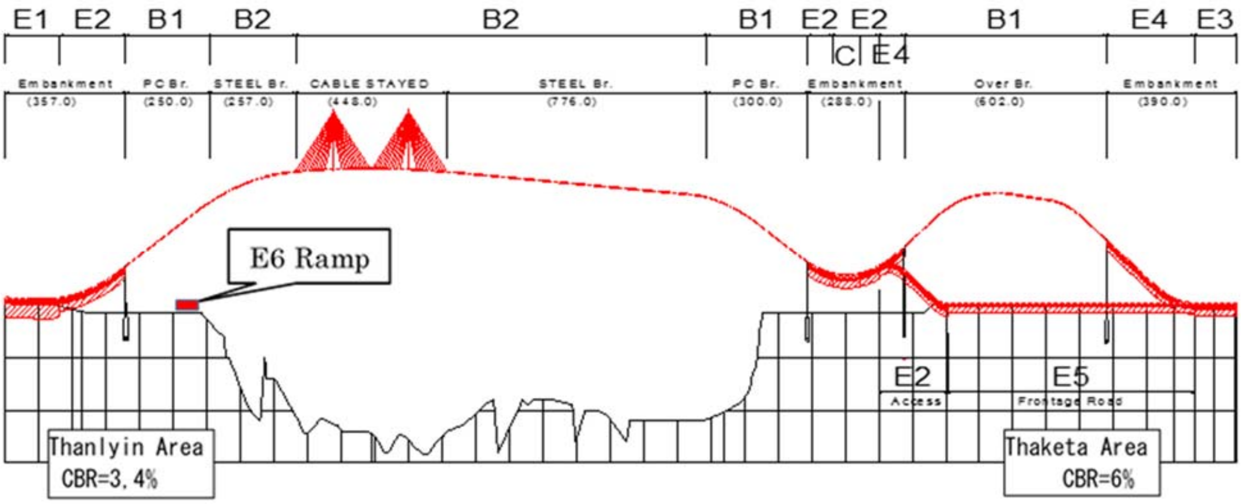
3.2 PAVEMENT DESIGN

3.2.1 Design Condition

The pavement should not only consider the traffic demand forecast but also the design that takes into consideration the bridge and embankment section. The generally required performance of pavement is as follows:

- Suitable pavement design for road structures including existing ground, embankment material, and bridge.
- Keep comfort and safety for driving.
- Keep durability to withstand vehicle load based on the traffic demand forecast.
- Select the pavement suitable for embankment and bridge structure.

Project road will be divided for suitable design of embankment and bridge section, as shown below. The embankment section is divided into seven types including concrete pavement while the bridge section is divided into two types.



Source: JICA Study Team

Figure 3.2.1 Pavement Sections

Table 3.2.1 Pavement Type

Pavement Section	Road Structure	Under the Pavement	Pavement Structures
E1, E3, E5, E6	Embankment	Cutting	Asphalt Pavement
E2, E4	Embankment	Filling	Asphalt Pavement
C	Toll Gate	Filling	Concrete Pavement
B1	PC-Box, Viaduct	RC Deck	Bridge Pavement
B2	Cable-stayed Bridge, Steel Box Girder	Steel Deck	Bridge Pavement

Source: JICA Study Team

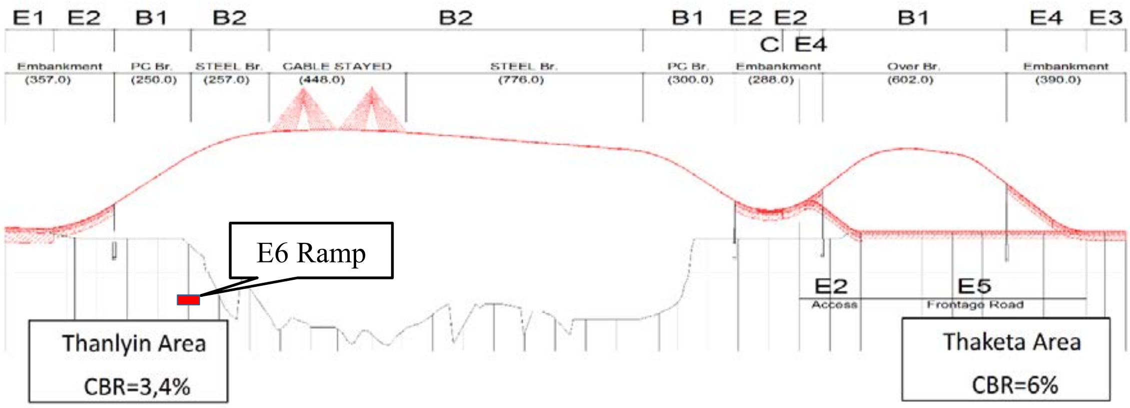
The pavement layer designs shall be based on the “AASHOTO Guide for Design of Pavement Structures 1993” for each pavement section. This reason is used it many countries in Asia, the dimensions and weight of the vehicles can reflect actual situation in Myanmar. The pavement of the bridge section will be designed considering waterproofness, durability, and economy based on past records of Japanese bridges.

3.2.2 Design of Embankment Section

3.2.2.1 Pavement Layer of Embankment

The pavement layer of embankment is shown in Figure 3.2.2.

Location	Thanlyin			Thaketa					
	Approach E1	Approach E2	Ramp E6	Toll E2	Ov Approach E4	Access Ramp E4	Ov Approach E4	Widenning E3	Frontage Road E5
DesignCBR	4.0 -	6.0 -	3.0 -	6.0 –				6.0 -	6.0 -
M_R (psi)	6000.0	9000.0	4500.0	9000.0					
a_1	0.440								
a_2	0.134								
a_3	0.109								
m	1.000								
Traffic	29,344,839	29,344,839	526,952	29,344,839	13,899,717	15,445,122	13,899,717	19,033,241	3,588,119
SN	5.028	4.503	3.061	4.503	4.014	4.081	4.014	4.216	3.222
Thickness of Pavemnet Structures									
As	10	10	10	10	10	10	10	10	10
Base Course	25	25	15	25	25	25	25	25	15
SubBase	50	35	15	35	25	25	25	30	25
SubGrade	-	-	-	-	-	-	-		-
Totall	85	70	40	70	60	60	60	65	50



Source: JICA Study Team

Figure 3.2.2 Pavement Layer List

The pavement of embankment is adopted straight asphalt pavement. This is because it is difficult to secure quantitative quality of improved asphalt as a result of hearings from local contractors. And it is one of the reason that it is easy to procure local materials.

3.2.2.2 Concrete Pavement

The thickness of concrete pavement is 9.1 inches (23 cm), rounded to 25 cm. The thickness of the upper subbase is set so that the total thickness which includes the lower subbase is the same as the asphalt pavement thickness.

Table 3.2.2 Pavement Thickness

Layer	Asphalt Pavement	Concrete Pavement
Surface Course ~ Upper Subbase	5 cm 5 cm 25 cm	25 cm 10 cm
Lower Subbase	35 cm	35 cm
Total	70 cm	70 cm

Source: JICA Study Team

3.2.3 Bridge Section

3.2.3.1 Steel Deck Section

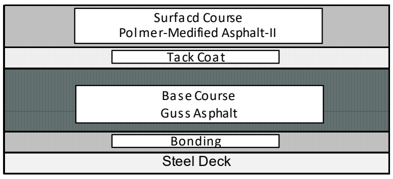
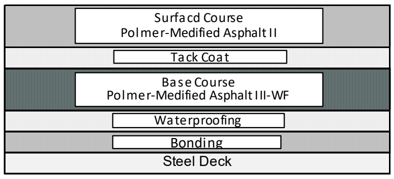
The steel deck section has different features from the embankment section, as follows:

- Road surface deflects easily; pavement has to follow this deflection.
- It is necessary to protect the steel deck from rainwater.
- It is necessary to have the bonding effect between pavement and steel deck.

As a result, there are two alternatives for pavement on steel decks, guss asphalt and improved asphalt.

As shown Table 3.2.3 improved asphalt is recommended.

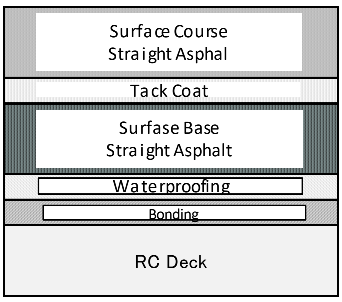
Table 3.2.3 Pavement for Steel Deck

	Case 1 GUSS ASPHALT		Case 2 IMPROVED ASPHALT	
Asphalt Layer				
Surface Course	Polmer-Modified Asphalt II t=40mm		Polmer-Modified Asphalt II t=40mm	
Tack Coat	0.4ℓ/㎡		0.4ℓ/㎡	
Base Course	Guss Asphalt t=40mm		Polmer-Modified Asphalt III-WF t=40mm	
Waterproofing	-		Hot-applied Asfalt Menmbrance Waterproofing	
Bonding	Solvent-type Rubber Asphalt Primer		Solvent-type Rubber Asphalt Primer	
Thickness	Total 80mm		Total 80mm	
Featuers	- Guss Asphalt has excellent flexibility. - Guss has Waterproofing featuer, unneccessary Waterlayer. - Special Construction Machines are required.	◎	- Improved Asphalt has excellent flexibility. - Waterlayer is necessary. - Can be constructed with normal Machines.	◎
Construction Period	3 Days/1000m2	○	1 Day/1000m2	◎
Maintain	- Special Construction Machines are required	○	- Improved Asphalt has easy maintain. - Can be constructed with normal Machines.	◎
COST	1.3	○	1.0	◎
Evaluation			Recommended	

Source: JICA Study Team

3.2.3.2 RC Deck Section

RC deck has less deck deflection than steel deck. For economical consideration, straight asphalt pavement is recommended.



Source: JICA Study Team

Figure 3.2.3 Pavement Layer on RC Deck

3.3 SOFT SOIL TREATMENT

3.3.1 Setting of the Analysis Block Classification

In the soft soil analysis, the areas are divided into blocks as shown in Table 3.3.1 in consideration of the ground conditions, among others.

Table 3.3.1 Analysis Block Classification

Area Name	Block Numbe	Stationary Point	Extension (m)	Embankment Height(m)	Soft Soil Layer Thickness(m)	Reason for Setting
Thanlyin Area	-	STA.0+000.000 ~ STA.0+130.000	130.0	0.41 ～ 0.6	-	It is the range planned on the current road, as it can be thought that it is being compacted at present condition, so it is out of the scope of consideration for soft ground treatment.
	Block1	STA.0+130.000 ~ STA.0+250.000	120.0	1.31 ～ 2.1	18	Low embankment structure.
	Block2	STA.0+250.000 ~ STA.0+322.000	110.0	2.1 ～ 3.51	18～20	An embankment structure on the upstream side and a retaining wall structure on the downstream side.
	Block3	STA.0+322.000 ~ STA.0+352.000	30.0	3.51 ～ 4.36	19～20	At the rear of the A1 bridge, the upstream side is the embankment structure and the downstream side is the retaining wall structure.
Thaketa Area	Block4	STA.2392.500 ~ STA.2+593.800	201.3	3.6 ～ 4.23	12～14	From the geological longitudinal map, the soft soil layers are composed of Filled soil, Clay-1 and Silty sand-1, with the embankment structure on the upstream side and the retaining wall structure on the downstream side.
	Block5	STA.2+593.800 ~ STA.2+676.000	82.2	3.56 ～ 4.37	12～13	The main line is a retaining wall structure, the approach road is an embankment structure on the upstream side, and the retaining wall structure on the downstream side.
	Block6	STA.2+676.000 ~ STA.2+800.000	124.0	0.5 ～ 4.37	9～12	Designed with a low embankment structure with one lane on one side of the approach road.
On-ramp	Block7	STA.0+000.000 ~ STA.0+367.483	367.5	0.22 ～ 2.57	17～20	Low embankment structure.
	Block8	STA.0+367.483 ~ STA.0+406.000	38.5	2.57 ～ 4.86	17～20	Retaining wall structure at the rear of the A1 bridge.

Source: JICA Study Team

3.3.2 Summary of the Analysis Result

The analysis results are summarized in Table 3.3.2., Table 3.3.3 and Table 3.3.4.

Table 3.3.2 Summary of Analysis Results (Thanlyin Side)

Block			Block 1		Block 2		Block 3	
Analysis cross section			STA.0+240		STA.0+320		STA.0+360	
Settlement analysis	Residual settlement (cm)		18.562		10.786		9.752	
	Allowable value (30 cm)		OK		OK		-	
	Allowable value (10 cm)		-		-		OK	
Transformation analysis			OK		OK		OK	
Liquefaction research			NG		NG		NG	
Safety analysis	Normal	At the time of construction	1.450	OK	1.434	OK	1.202	OK
		At the time of service	1.450	OK	1.434	OK	1.202	NG
	At the time of earthquake		1.226	OK	0.876	NG	0.895	NG
	At the time of liquefaction		1.564	OK	1.199	OK	1.047	NG

Lateral movement	-	-	2.00	NG
Retaining wall bearing capacity	-	NG	NG	

Source: JICA Study Team

Table 3.3.3 Summary of Analysis Results (Thaketa Side)

Block			Block 4		Block 5		Block 6	
Analysis cross section			STA.2+400		STA.2+620		STA.2+680	
Settlement analysis	Residual settlement (cm)		27.632		2.915		3.436	
	Allowable value (30 cm)		OK		OK		OK	
	Allowable value (10 cm)		NG		OK		-	
Transformation analysis			OK		OK		OK	
Liquefaction research			NG		NG		NG	
Safety analysis	Normal	At the time of construction	1.226	OK	1.282	OK	1.880	OK
		At the time of service	1.226	NG	1.282	OK	1.880	OK
	At the time of earthquake		0.895	NG	1.027	NG	1.466	OK
	At the time of liquefaction		1.379	OK	1.347	OK	1.772	OK
Lateral movement			0.762	OK	0.391	OK	-	
Retaining wall bearing capacity			NG		NG		-	

Source: JICA Study Team

Table 3.3.4 Summary of Analysis Results (On-ramp)

Block			Block 7		Block 8	
Analysis cross section			STA.0+360		STA.0+400	
Settlement analysis	Residual settlement (cm)		8.146		5.620	
	Allowable value (30 cm)		OK		OK	
	Allowable value (10 cm)		-		OK	
Transformation analysis			NG		NG	
Liquefaction research			NG		NG	
Safety analysis	Normal	At the time of construction	1.635	OK	1.161	OK
		At the time of service	1.635	OK	1.161	NG
	At the time of earthquake		1.207	OK	1.072	NG
	At the time of liquefaction		2.413	OK	0.819	NG
Lateral movement					3.167	NG
Retaining wall bearing capacity					NG	

Source: JICA Study Team

3.3.3 Selection of Countermeasures

The necessary countermeasures in each cross section will be considered based on the analysis results.

3.3.3.1 Thanlyin Side

Table 3.3.5 shows the necessary measures and countermeasures in each cross section on the Thanlyin side.

Table 3.3.5 Countermeasure (Thanlyin Side)

Block	Block 1	Block 2	Block 3
Analysis section	STA.0+240.000	STA.0+320.000	STA.0+340.000
Settlement measure	Not needed	Not needed	Not needed
Transformation measure	Not needed	Not needed	Not needed
Stability measure	Not needed	Needed	Needed
Lateral movement measure	-	-	Needed
Retaining wall bearing capacity measure	-	Needed	Needed
Countermeasure	Method of loading banking load	Method of loading banking load + Deep mixing method	Deep mixing method

Source: JICA Study Team

3.3.3.2 Thaketa Side

Table 3.3.6 shows the necessary measures and countermeasures in each cross section on the Thaketa side.

Table 3.3.6 Countermeasures (Thaketa Side)

Block	Block 4	Block 5	Block 6
Analysis section	STA.2+440.000	STA.2+620.000	STA.2+680.000
Settlement measure	Needed	Not needed	Not needed
Transformation measure	Not needed	Not needed	Not needed
Stability measure	Needed	Needed	Not needed
Lateral movement measure	Not needed	Not needed	-
Retaining wall bearing capacity measure	Needed	Needed	-
Countermeasure	Method of loading banking load + Deep mixing method	Method of loading banking load + Deep mixing method	Slow loading method

Source: JICA Study Team

3.3.3.3 On-ramp

Table 3.3.7 shows the necessary measures and countermeasures in each cross section on the on-ramp.

Table 3.3.7 Countermeasures (On-ramp)

Block	Block 7	Block 8
Analysis section	STA.0+360.000	STA.0+400.000
Settlement measure	Not needed	Not needed
Transformation measure	Needed	Not needed
Stability measure	Not needed	Needed
Lateral movement measure	-	Needed
Retaining wall bearing capacity measure	-	Needed
Countermeasure	Slow loading method	Deep mixing method

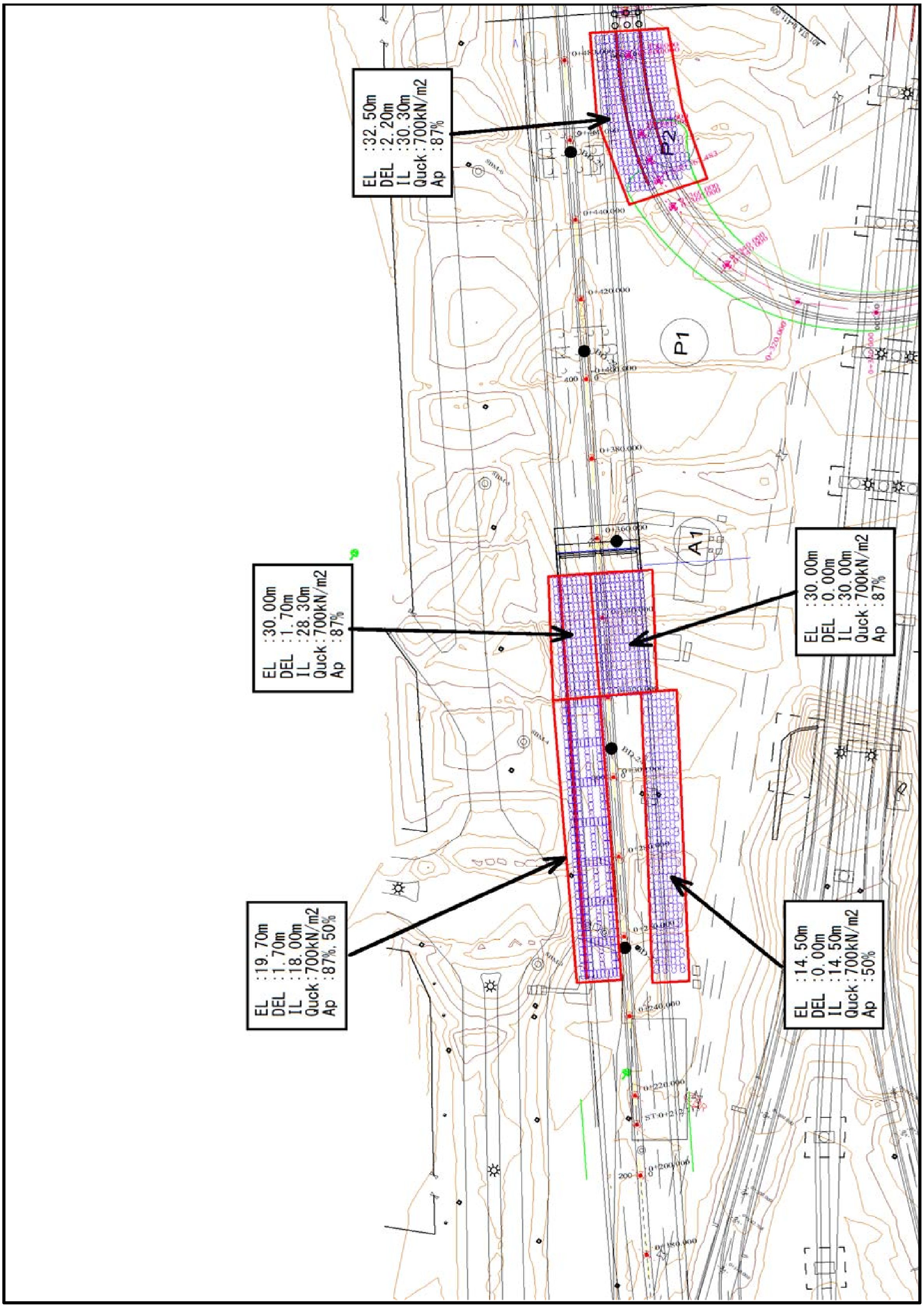
Source: JICA Study Team

3.3.4 Ground Analysis after Countermeasure (Deep Mixing Method)

Deep mixing method is a ground improvement method by first supplying cement and other modifying materials underground as measures against settlement of embankment, circular slip of embankment, lateral movement of abutment, and bearing capacity of retaining wall, then moderately solidifying the ground by mixing and stirring forcibly with the original ground.

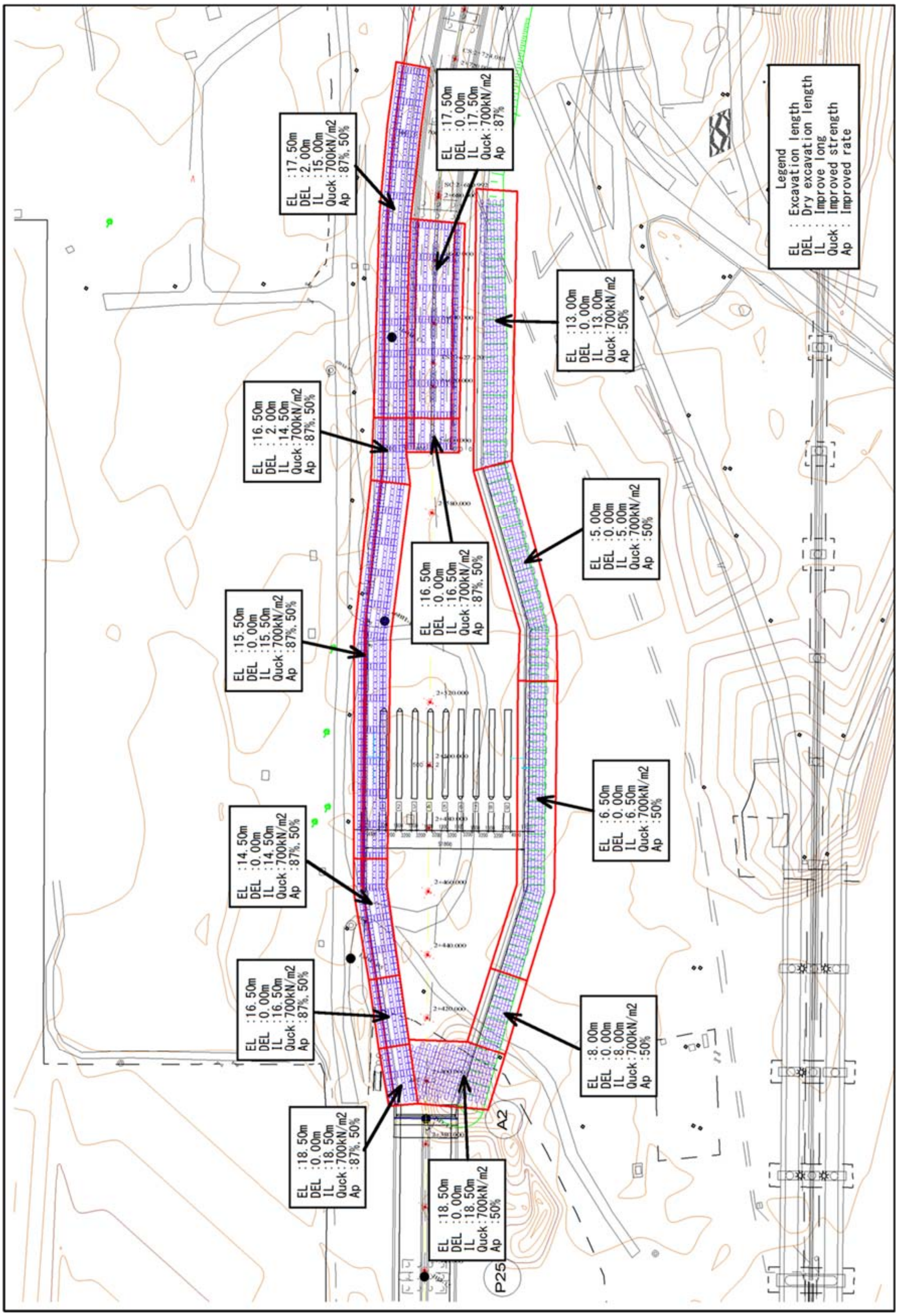
- Result of the Ground Analysis after Design

The column layout diagrams of the deep mixing method are shown in Figure 3.3.1 to Figure 3.3.2.



Source: JICA Study Team

Figure 3.3.1 Column Layout (Thanlyin Side)



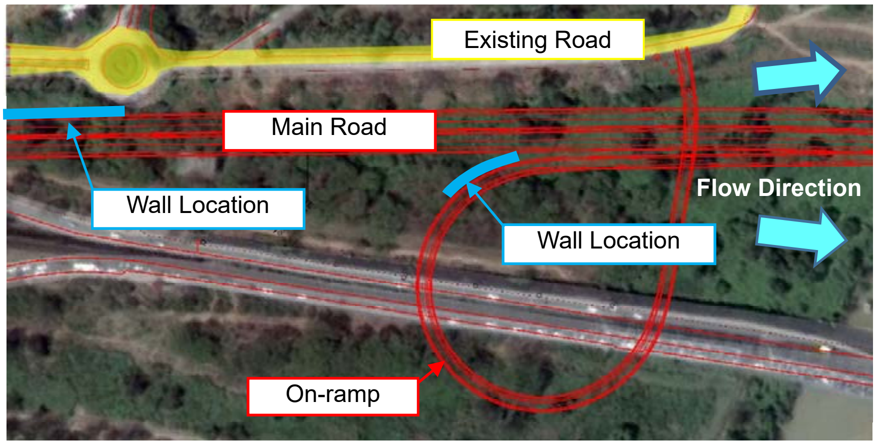
Source: JICA Study Team

Figure 3.3.2 Column Layout (Thaketa Side) The analysis result of the ground after design is described below.

3.4 ROAD STRUCTURE DESIGN

3.4.1 Location of Road Structures

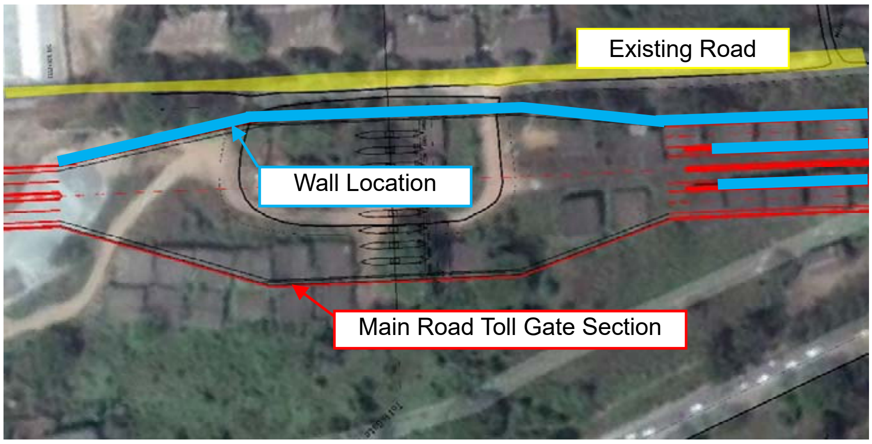
The plan on the left bank side is shown in Figure 3.4.1 below. Since the Project road is close and parallel to the current road, the retaining walls are set up at the downstream side of the main road and behind the ramp abutment.



Source: JICA Study Team

Figure 3.4.1 Location of the Road Structures on the Left Bank

The plan on the right bank side is shown in Figure 3.4.2 below. Since the planned toll gate is close to the current road and border, and the opening is very narrow, the retaining wall needs to be set up on the downstream side of the main road.

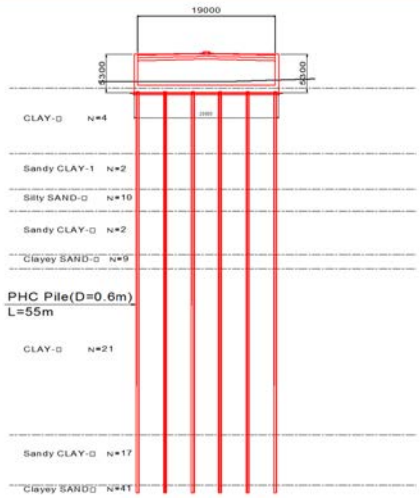
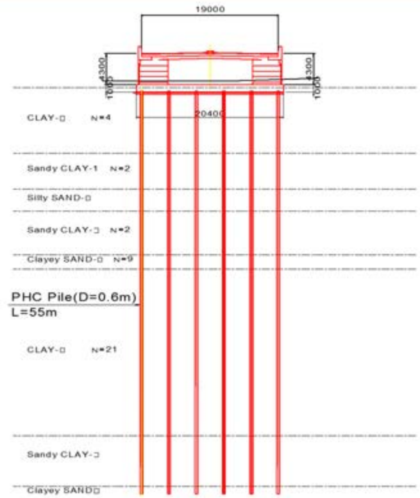
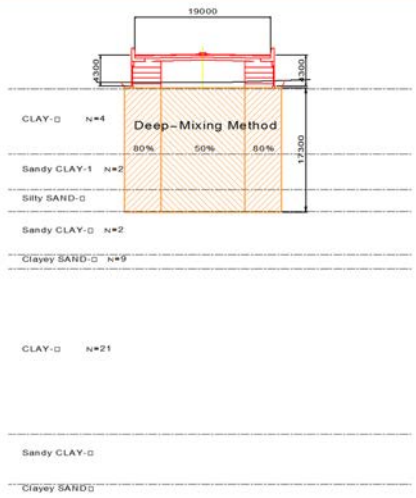


Source: JICA Study Team

Figure 3.4.2 Location of the Road Structures on the Right Bank

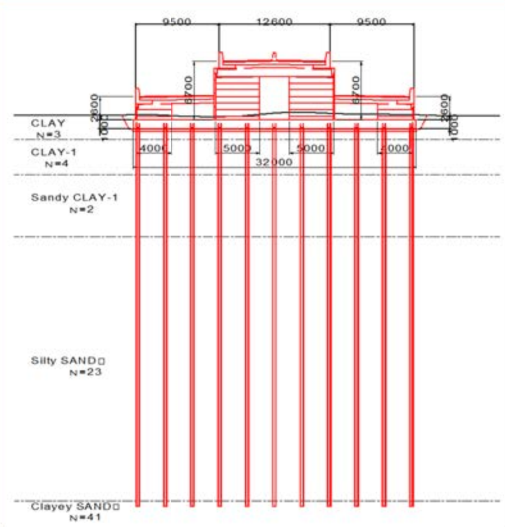
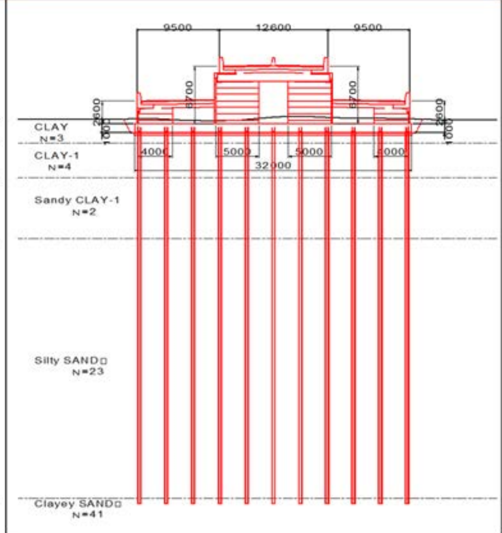
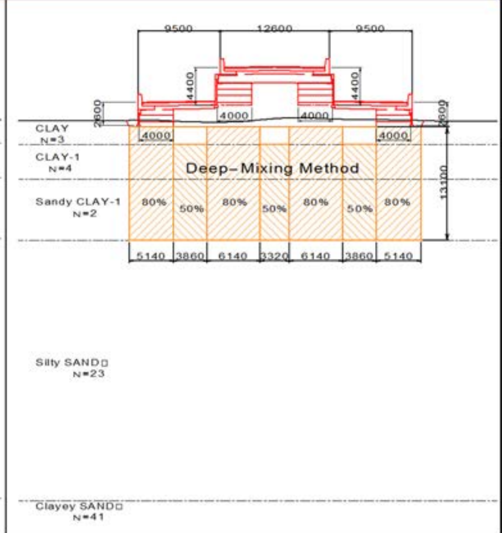
3.4.2 Selection of Road Structures

The selection of road structures considers the type of retaining wall and foundation method. The comparison is carried out including retaining wall with foundation, and three types are examined. The three types compared are shown in Figure 3.4.3 to Figure 3.4.5 below.

	Case 1 Retaing Concrete Wall with Piles		Case 2 Mechanically-Stabilided Earth Wall with Piles and Slab		Case 3 Mechanically-Stabilized Earth Wall with Deep-Mixing Method	
Schematic Section						
Construction Outline	Adapt U-Type Wall. Pile Foundation under the Wall Footing.		Adapt Reinforced Soil Wall. The foundation is PHC piles with slab.		Adapted Reinforced Soil Wall. The foundation is Deep-Mixing Method.	
Foundation Structal Feature	- The piles are PHC, diameter 500mm - The piles are anchored clay sand II, N value is more than 41.	○	- The piles are PHC, diameter 500mm - The piles are anchored clay sand II, N value is more than 41.	○	- Under the Reinforced Soil Wall has 80% rate of treatment. - The rate of other parts are 50%. - Deep-Mixing Method is anchored sandy silt, N value is more than 23.	○
Construction Period	6.9 days/m	○	5.9 days/m	◎	6.1 days/m	◎
Cost Ratio	1.44	○	1.03	○	1.00	◎
Evaluation					**Most Recommended**	

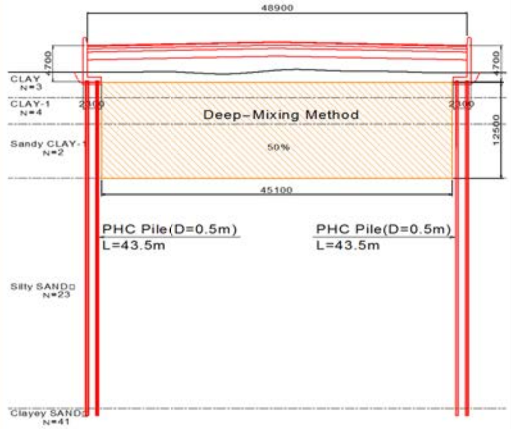
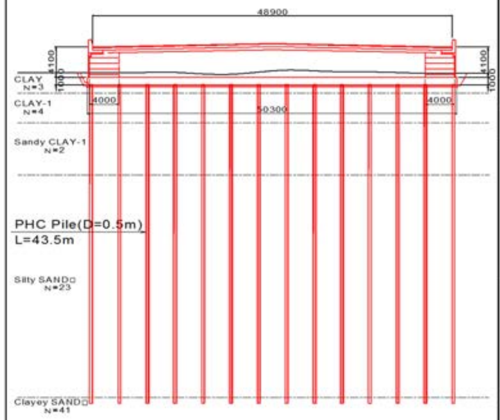
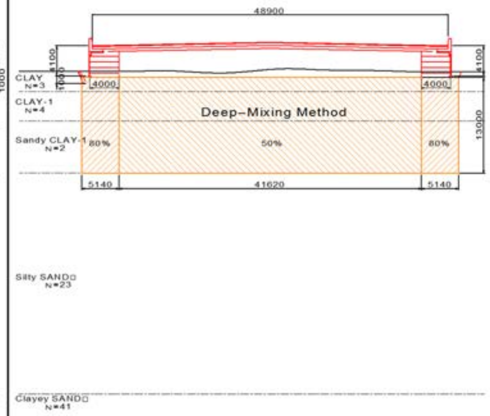
Source: JICA Study Team

Figure 3.4.3 Comparison of Retaining Wall with Foundation (Left Bank Side)

	Case 1 Retaing Concrete Wall with Piles		Case 2 Mechanically-Stabilided Earth Wall with Piles and Slab		Case 3 Mechanically-Stabilized Earth Wall with Deep-Mixing Method	
Schematic Section						
Construction Outline	Main road is adapted U-type Wall. The piles foundation under the walls. Other area inserts Deep-Mixing Method.		Main road and Ramp are adapted Reinforced soil wall. Foundation is PHC piles and slab.		Main road and Ramp are adapted Reinforced soil wall. Foundation is Deep-Mixing Method.	
Foundation Structal Feature	- Piles are PHC, diameter 500mm. - The piles are anchored clay sand II - N value is more than 41. - Deep-Mixing Method is anchored sandy silt.	○	- Piles are PHC, diameter 500mm. - The piles are anchored clay sand II - N value is more than 41.	○	- Under the Reinforced Soil Wall has 80% rate of treatment. - The rate of other parts are 50%. - Deep-Mixing Method is anchored sandy silt, N value is more than 23.	◎
Construction Period	10.6 days/m	○	10.6 days/m	○	9.8 days/m	◎
Cost Ratio	1.14	○	1.52	○	1.00	◎
Evaluation					Most Recommended	

Source: JICA Study Team

Figure 3.4.4 Comparison of Retaining Wall with Foundation (Right Bank Side)

	Case 1 Retaing Concrete Wall with Piles		Case 2 Mechanically-Stabilided Earth Wall with Piles and Slab		Case 3 Mechanically-Stabilized Earth Wall with Deep-Mixing Method	
Schematic Section						
Construction Outline	Adapt U-Type Wall. Pile Foundation under the Wall Footing.		Adapt Reinforced Soil Wall. The foundation is PHC piles with slab.		Adapted Reinforced Soil Wall. The foundation is Deep-Mixing Methodt.	
Foundation Structal Feature	- The piles are PHC, diameter 500mm - The piles are anchored clay sand II, N value is more than 41.	○	- The piles are PHC, diameter 500mm - The piles are anchored clay sand II, N value is more than 41.	○	- Under the Reinforced Soil Wall has 80% rate of treatment. - The rate of other parts is 50%. - Deep-Mixing Method is anchored sandy silt, N value is more than 23.	○
Construction Period	9.7 days/m	◎	12.2 days/m	○	10.1 days/m	◎
Cost Ratio	1.14	○	1.49	○	1.00	◎
Evaluation					Most Recommended	

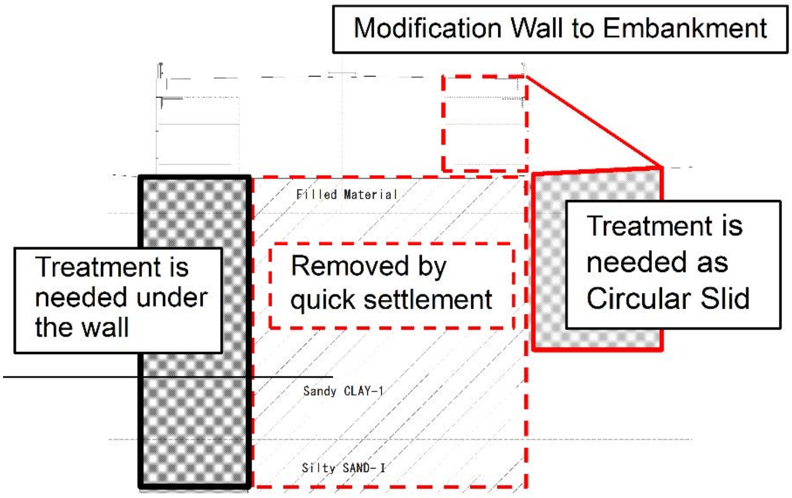
Source: JICA Study Team

Figure 3.4.5 Comparison of Retaining Wall with Foundation (Toll Gate Section)

As a result of the comparison, the reinforced soil wall with soft soil treatment is better than the other wall structures. In this Project, the road structure selects this wall and foundation structure.

3.4.2.1 Combination with Surcharge

The cost of the road structures will bear the high cost of the soft soil improvement. Therefore, the reduction of the area of soft soil improvement will be studied. The bottom of the wall needs soft soil improvement for stability, and soft soil improvement outside the wall is also needed for settlement measure. For this reason, it is possible to change the method from soft soil improvement to surcharge. Especially, the effect of cost reduction is expected in the toll gate section which has a wide width.



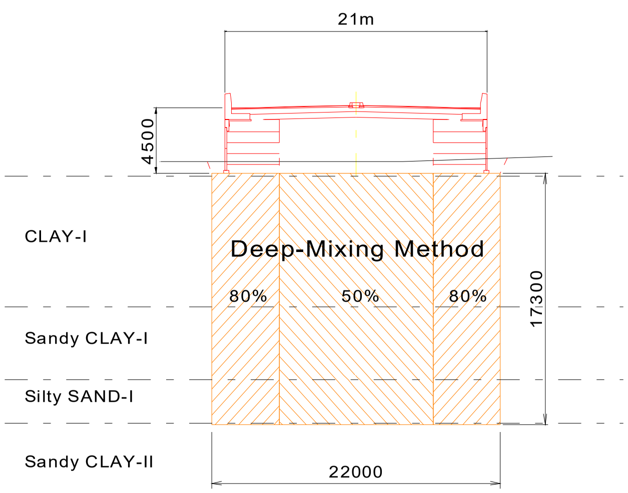
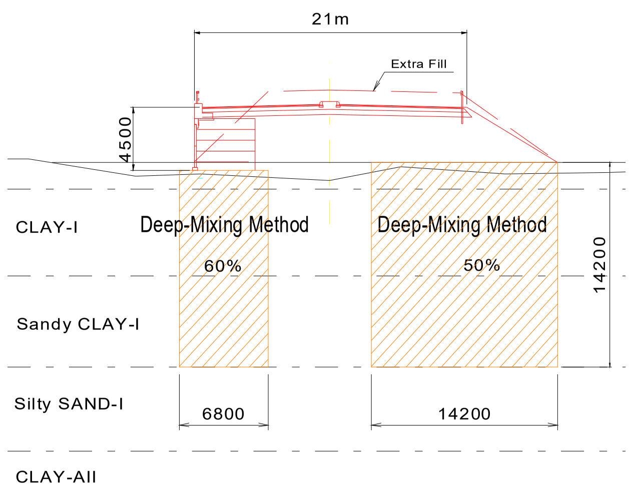
Source: JICA Study Team

Figure 3.4.6 Section Where to Apply the Surcharge Method

Surcharge method will be applied on both the left and right banks. The comparison of road structures with modified foundation structures is shown below.

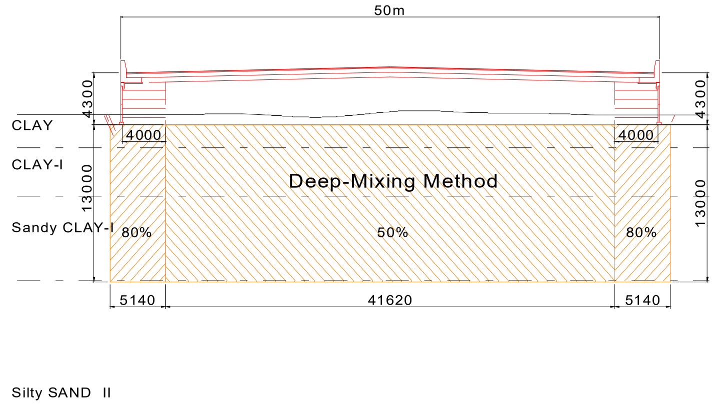
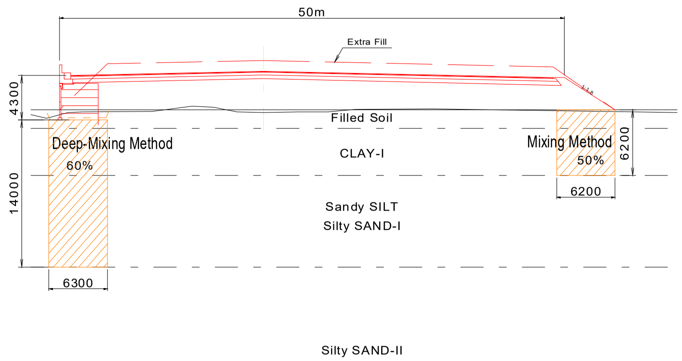
3.4.2.2 Gravity Wall

In the Thaketa section, the retaining wall near the intersection is gravity wall, The height is less than H=2.0 m. Shallow improvement is proposed to ensure the bearing capacity of the Clay-1 layer. The amount of cement added is based on the result in the New Thaketa Bridge. The amount of cement to be added is 110 kg/m^3, but during construction, it is necessary to secure more than 290 kN/m^2.

	Basic Design		Detail Design	
Schematic Section				
Construction Outline	- Adapted Reinforced Soil Wall both side. - The Mixing Method is Full Width.		- Adapted Reinforced Soil Wall one side. - The Mixing Method is under the wall and Embankment Edge. - The Extra Fill for quick settlemet.	
Foundation Structal Feature	- The rate of Soft Soil Treatment is 80% under the Wall. - The Embankment Wdge is 50% based on latest geological survey.	○	- Adapted Mixing Method at Embankmet Edge as Countermesure Circular Slip. - The rate of Soft Soil Treatment is 60% under the Wall. - The Embankment Edge is 50% based on latest geological survey.	○
Construction Period	6.1 days/m	○	5.1 days/m	◎
Cost Ratio	1.37	○	1.00	◎
Evaluation			Most Recommended	

Source: JICA Study Team

Figure 3.4.7 Changing to Surcharge Method (Left Bank)

	Basic Design		Detail Design	
Schematic Section				
Construction Outline	- Adapted Reinforced Soil Wall both side. - The Mixing Method is Full Width.		- Adapted Reinforced Soil Wall one side. - The Mixing Method is under the wall and Embankment Edge. - The Extra Fill for quick settlemet.	
Foundation Structal Feature	- The rate of Soft Soil Treatment is 80% under the Wall. - The Embankment Wdge is 50% based on latest geological survey.	○	- Adapted Mixing Method at Embankmet Edge as Countermesure Circular Slip. - The rate of Soft Soil Treatment is 60% under the Wall. - The Embankment Edge is 50% based on latest geological survey.	○
Construction Period	10.1 days/m	○	4.4 days/m	◎
Cost Ratio	4.19	○	1.00	◎
Evaluation			Most Recommended	

Source: JICA Study Team

Figure 3.4.8 Changing to Surcharge Method (Right Bank)

3.5 FLYOVER AND WIDENING OF THANLYIN CHIN KAT ROAD

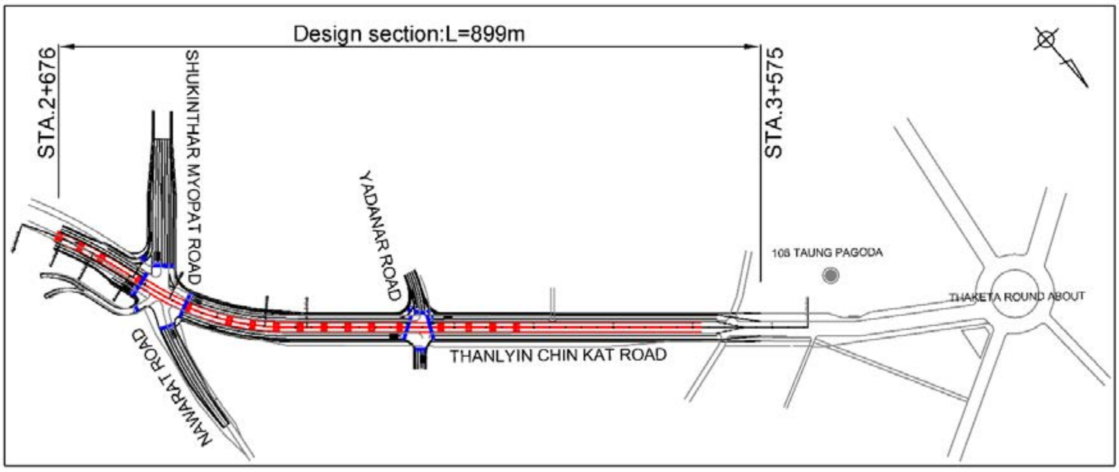
3.5.1 Design Conditions

(1) Project Site for Flyover and Widening of Thanlyin Chin Kat Road

The site for the Thanlyin Chin Kat Road flyover and widening project is as follows:

- Beginning point (STA.2+676): The beginning point is the A1 abutment of the flyover.
- End point (STA.3+575): The end point is the taper end merged to the existing Thanlyin Chin Kat Road after the flyover connects to the at-grade road.

The design section for the Thanlyin Chin Kat Road flyover and widening project is shown in Figure 3.5.1.

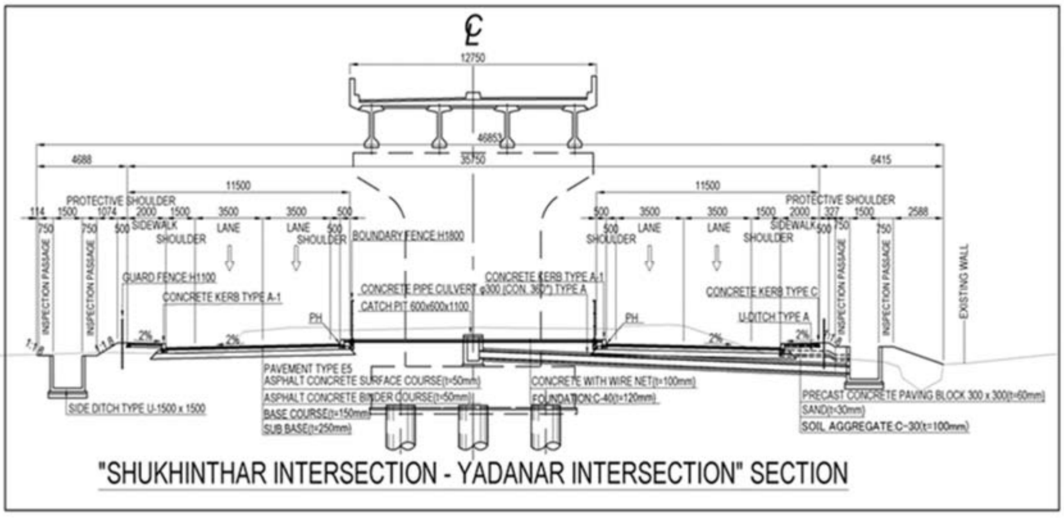


Source: JICA Study Team

Figure 3.5.1 Design Section for Flyover and Widening of Thanlyin Chin Kat Road

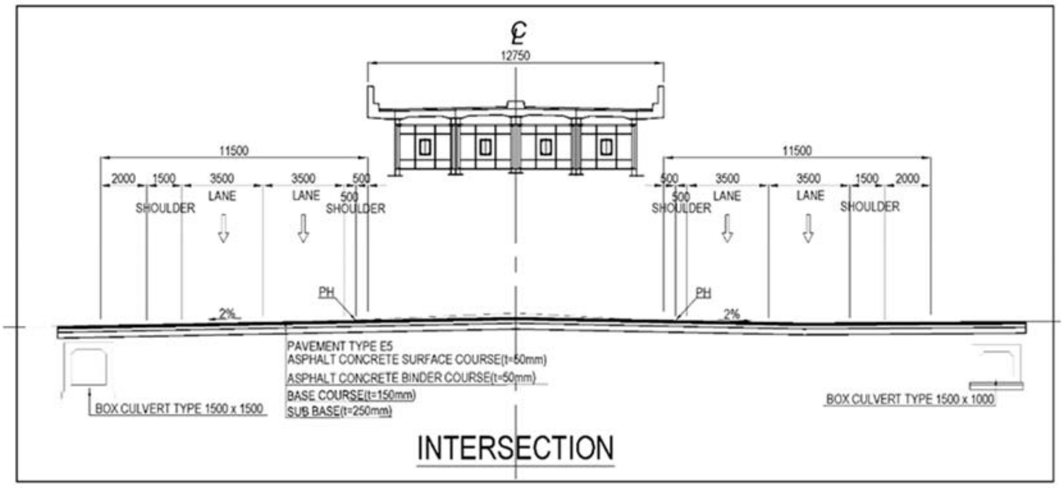
(2) Typical Cross Section

Typical cross section for the Thanlyin Chin Kat Road widening is shown in Figure 3.5.2 to Figure 3.5.5. Typical cross section for the flyover is the same as that of the main route.



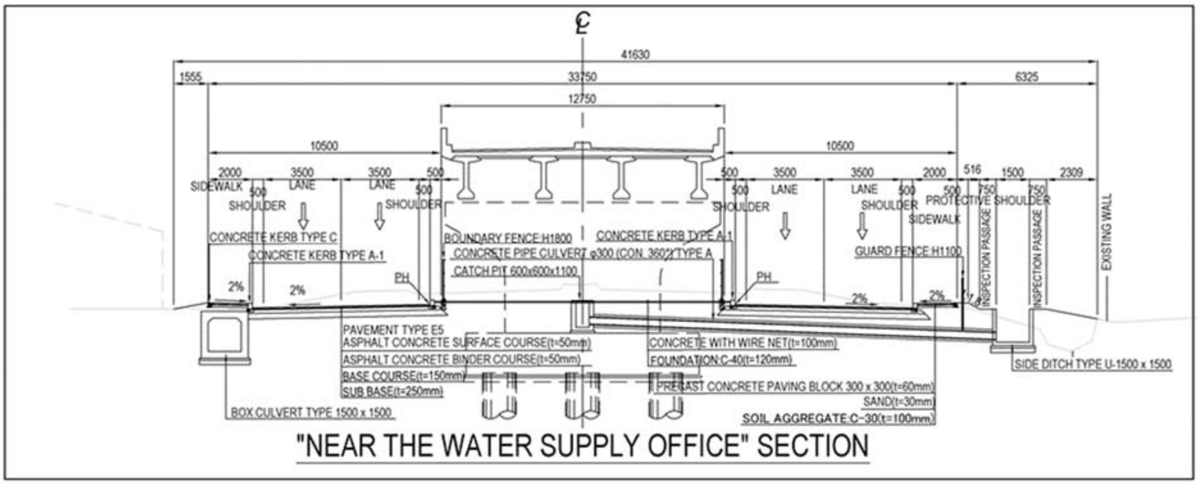
Source: JICA Study Team

Figure 3.5.2 Typical Cross Section: "Shukhinthar Intersection-Yadanar Intersection"



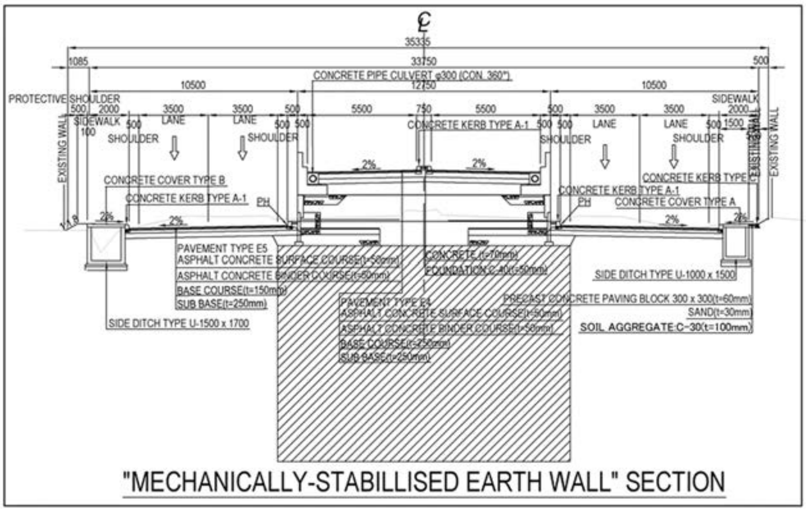
Source: JICA Study Team

Figure 3.5.3 Typical Cross Section: "In the Intersection"



Source: JICA Study Team

Figure 3.5.4 Typical Cross Section: "Near the Water Supply Office"



Source: JICA Study Team

Figure 3.5.5 Typical Cross Section: "Mechanically-stabilized Earth Wall"

(3) Type of Median Strip

"Raised median strip" was selected as the median strip on the flyover from the following reasons;

- Physical separation is necessary to prevent the deviation from oncoming traffic lane in consideration of driving manner in Myanmar
- "Rigid barrier" is inferior to "Raid median strip" in emergency use of flyover (emergency cars cannot pass over the oncoming lane)

Table 3.5.1 Type of Median Strip on the Flyover

Item		Flat	Raised	Barrier
Schematic Picture				
Structural Feature		Continuous asphalt plane with rubber poles / delineators	Concrete curb with height of 250mm	Rigid concrete wall barrier or steel railing
Function	Separation of lane	Semi-separated by pole or line	Physically separated by curb	Physically separated by barrier
	Anti-Deviation	Low	Medium	High
	Emergency use*1	Possible	Possible	Impossible
Oppression to drivers		Low	Low	High
Suitable/Applicable Site Condition*2		-Min.curve radius : R≧300m -Design speed : V ≦ 60km -Vertical gradient : i < 4%	-Min.curve radius : R≧300m -Design speed : V ≦ 60km -Vertical gradient : i < 4%	-Min.curve radius : R<300m -Design speed : V≧80km/h -Vertical gradient : i ≧ 4%
Installation Cost		Low	Moderate	Very High*3

*1 Emergency cars can physically pass over the median
*2 Minimum curve radius : R=320m, Max. i = 3% shall be applied to flyover
*3 Construction cost would be very high since width of F/O have to be widen due to incursion to artificial limit on S-curve section

Source: JICA Study Team

3.5.2 Alignment of the Flyover

(1) Horizontal Alignment

Outline of Horizontal alignment of the flyover section is shown in Figure 3.5.6.

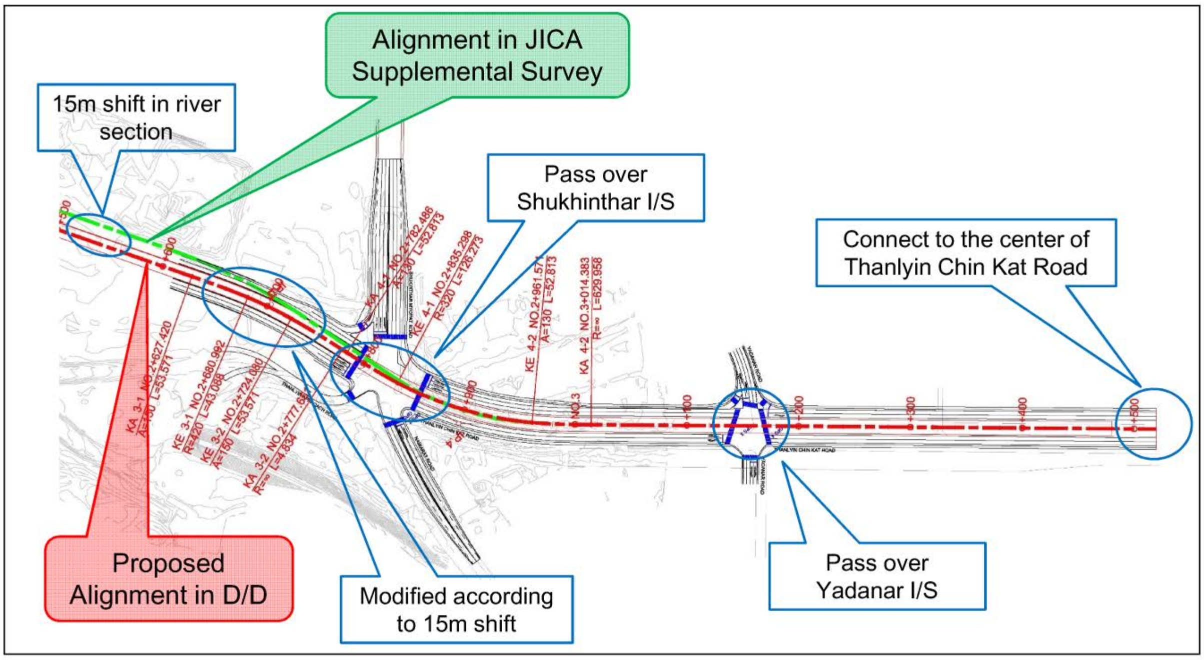
(2) Vertical Alignment

The vertical alignment of the flyover is shown in Figure 3.5.7, and it was determined taking into account the following conditions:

- Applying 3.0% as maximum vertical gradient in consideration of smooth driving of heavy vehicles.
- Applying 0.5% as minimum vertical gradient in consideration of discharge of rainwater from the road surface.
- Applying 5.5 m of vertical clearance under the flyover based on the request of YCDC.

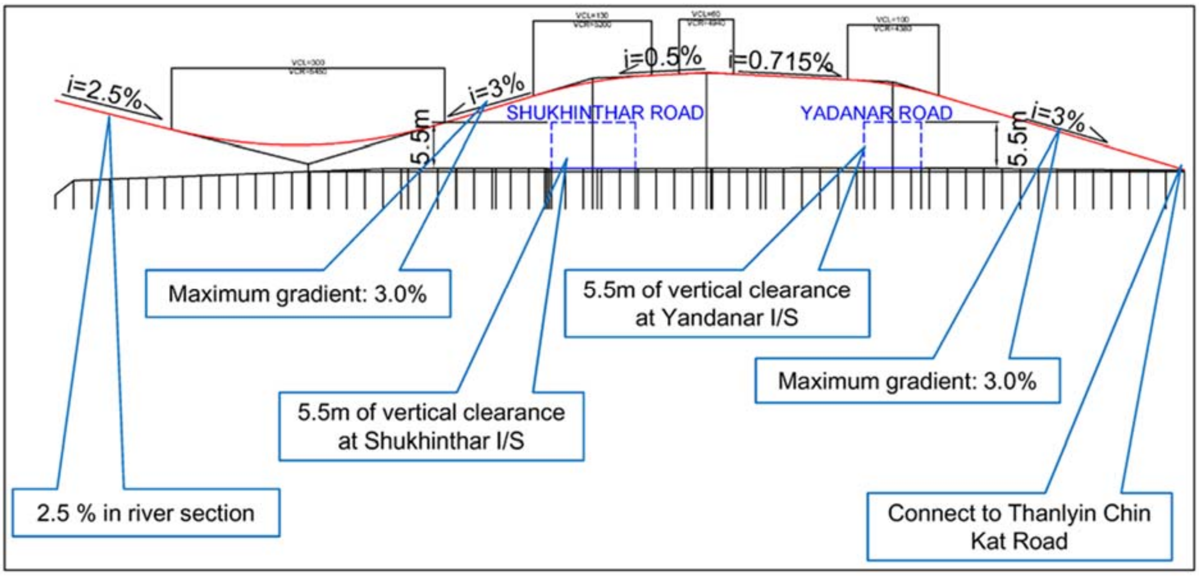
  Ensuring 5.5 m of vertical clearance at Shukhintar Intersection

  Ensuring 5.5 m of vertical clearance at Yadanar Intersection



Source: JICA Study Team

Figure 3.5.6 Outline of the Horizontal Alignment of the Flyover



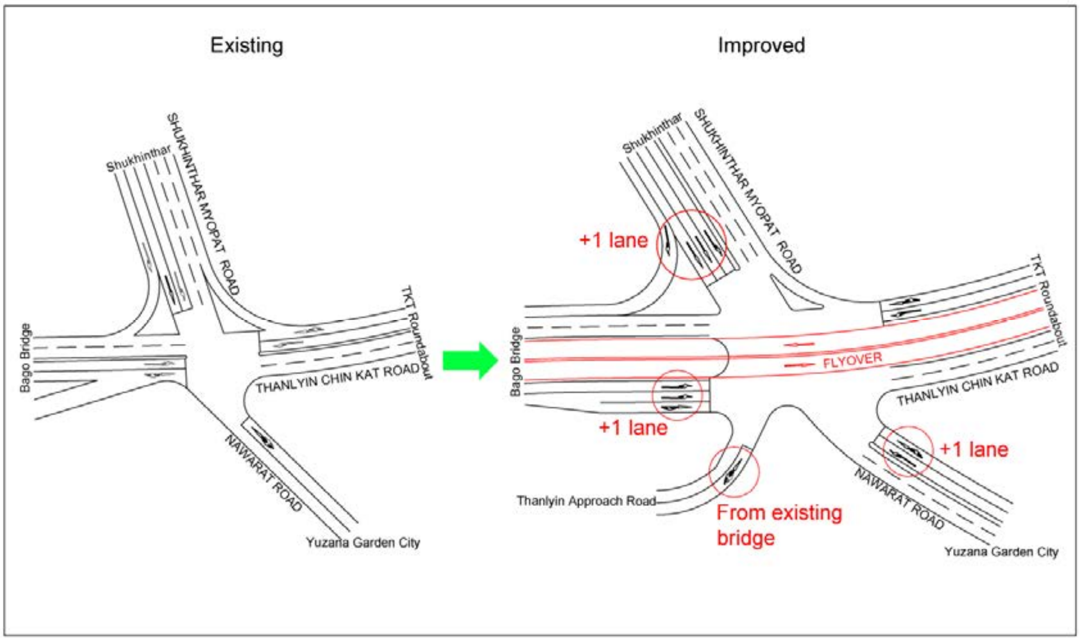
Source: JICA Study Team

Figure 3.5.7 Outline of the Vertical Alignment of the Flyover

3.5.3 Intersection Design

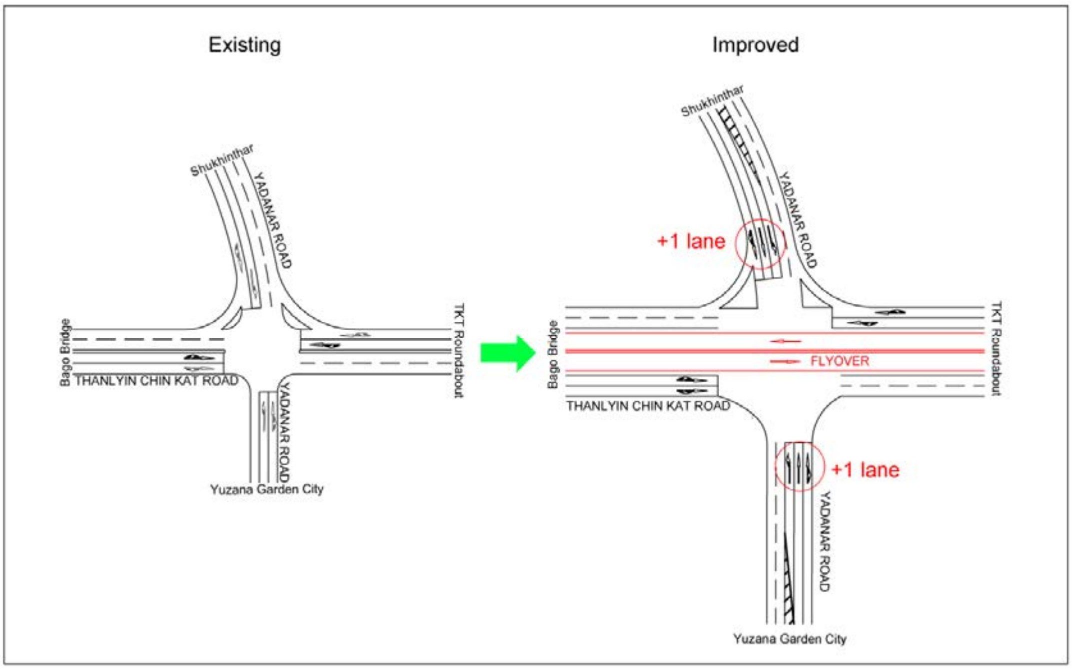
(1) Improvement of Intersection

Based on the intersection capacity analysis, Shukhinthar Intersection and Yadanar Intersection will be improved as shown in Figure 3.5.8 and Figure 3.5.9.



Source: JICA Study Team

Figure 3.5.8 Improvement of Shukhinthar Intersection



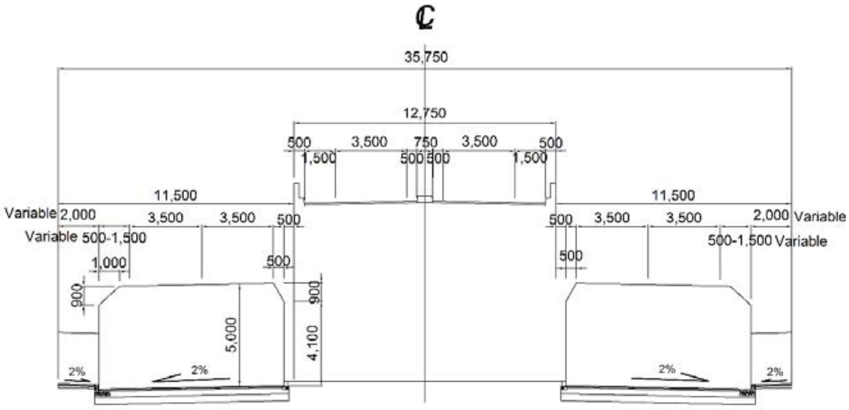
Source: JICA Study Team

Figure 3.5.9 Improvement of Yadanar Intersection

3.5.4 Earthwork

3.5.4.1 Selection of Retaining Wall Structure Type

A vertical wall type should be applied as the retaining wall structure for the approach road in the flyover section in order to minimize the road width as well as land acquisition. Some alternatives are prepared considering the maximum wall height (approximately 7 m) and the ground condition (soft soil ground). The appropriate structure type will be determined considering construction cost, structural stability, and construction period.

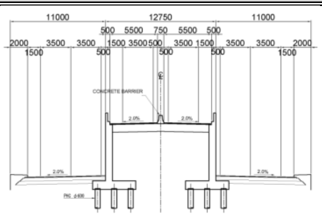
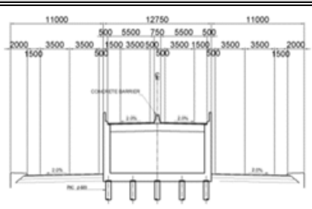
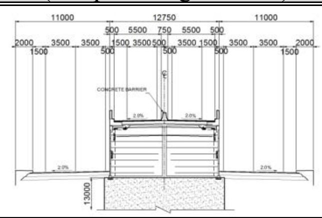


Source: JICA Study Team

Figure 3.5.10 Typical Cross Section for Approach Road on Flyover Section

As a result of the comparative study, "Alternative-3: Mechanically-stabilized Earth Wall + Soft Soil Ground Treatment by Deep Mixing Method" is selected for the retaining wall of the approach road in the flyover section as given in Table 3.5.2.

Table 3.5.2 Selection of Retaining Wall Structure

Evaluation Item	Alt-1 Cantilever Retaining Wall (T-shape) + Pile Foundation		Alt-2 U-shape Retaining Wall + Pile Foundation (Plan at F/S)		Alt-3 Mechanically-stabilized Earth Wall + Soft Ground Treatment (Deep Mixing Method)	
Schematic View						
Structural Aspect	Applicable wall height: 3-10 m Supported by piles for structural stability	Fair	Applicable wall height: Any Supported by piles for structural stability No. of piles is less than Alt-1 due to less uneven earth pressure	Good	Applicable span length: 3-18 m Soft ground treatment is necessary	Fair
Construction Cost	Ratio = 1.94	Poor	Ratio = 1.33	Fair	Ratio = 1.00	Good
Construction Period	3.7 months / 20 m	Poor	3.9 months / 20 m	Poor	1.1 months / 20 m	Good
Evaluation					**Recommended**	

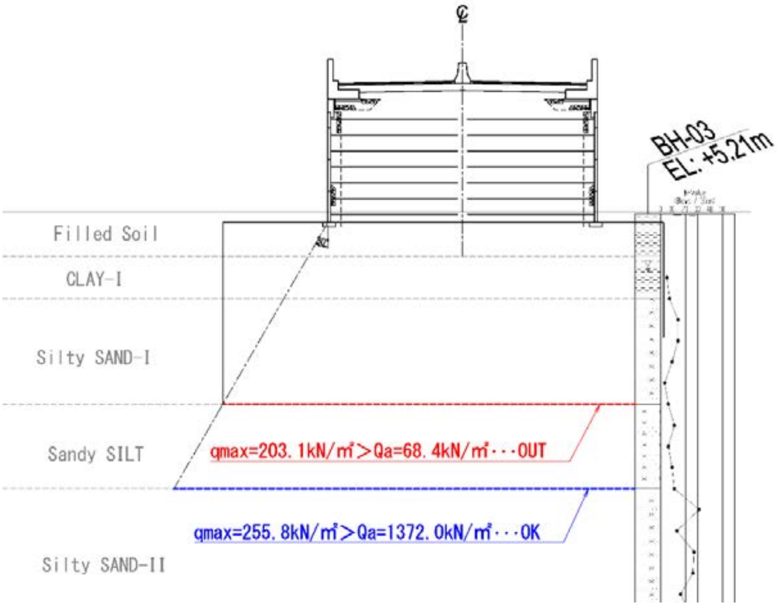
Source: JICA Study Team

3.5.4.2 Soft Ground Treatment

(1) Applied Soft Ground Treatment Method and Depth

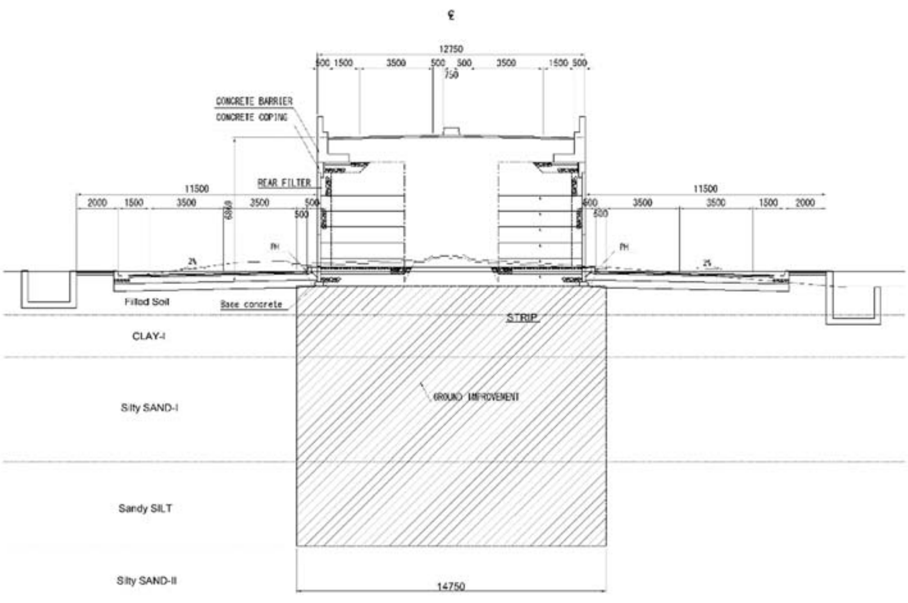
As described above, consolidation settlement of cohesive soil due to the new embankment and liquefaction due to earthquakes are a concern in the flyover section and soft ground treatment is required for the approach road in the flyover section.

"Deep mixing method" is applied as the soft ground treatment in the flyover section as well as other sections. The depth of soft ground treatment can be determined by the required bearing capacity under the mechanically-stabilized earth wall as given in Figure 3.5.11. As a result, soft ground treatment should be applied to the bottom level of the Sandy Silt layer.



Source: JICA Study Team

Figure 3.5.11 Verification Result of Bearing Capacity of Mechanically-stabilized Earth Wall



Source: JICA Study Team

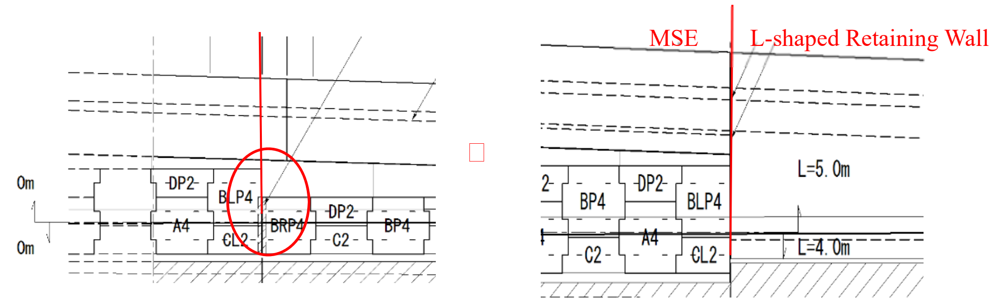
Figure 3.5.12 Typical Cross Section of Mechanically-stabilized Earth Wall

3.5.5 Detailed Design of Retaining Wall

3.5.5.1 Major Updates in Detailed Design from Basic Design

(1) Installation Area for Mechanically-stabilized Earth Wall

A mechanically-stabilized earth wall will be installed in the embankment section behind the abutment of the flyover. However, an L-shaped retaining wall will be installed in the low embankment section, where the number of mechanically-stabilized earth wall panel is one or less.

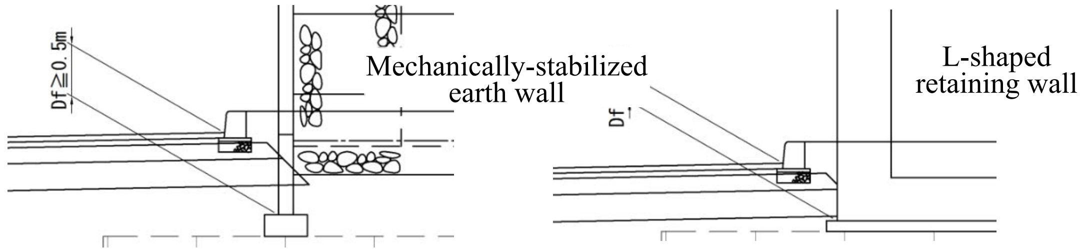


Source: JICA Study Team

Figure 3.5.13 Area for Mechanically-stabilized Earth Wall

(2) Foundation Embedment

Embedded depth of the foundation for both mechanically-stabilized earth wall and L-shaped retaining wall is set as 0.5 m or more.



Source: JICA Study Team

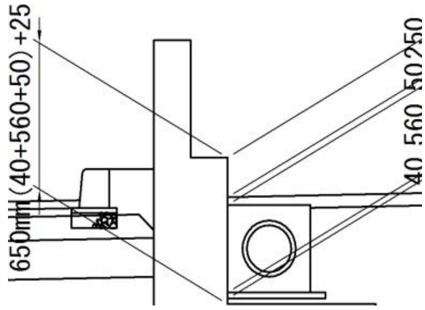
Figure 3.5.14 Depth of Foundation Embedment

(3) Adoption of L-shaped Retaining Wall

The drainage facility in the approach section is installed at a depth of 650mm, which consists of 50mm (pavement) +560mm (the height of drainage) +40mm (mortar layer). The required height of retaining wall is 900mm that the total of 560mm and 250mm of the curb height.

Gravity retaining wall is generally applied if the height of wall is less than 3m. However, L-shaped retaining wall was applied because it is more stable than gravity retaining wall when the 1/3 or 1/2 of the cross section is reduced due to the drainage facility.

The interval of joint was basically determined as 10m similar to the shrinkage joint on the parapet.

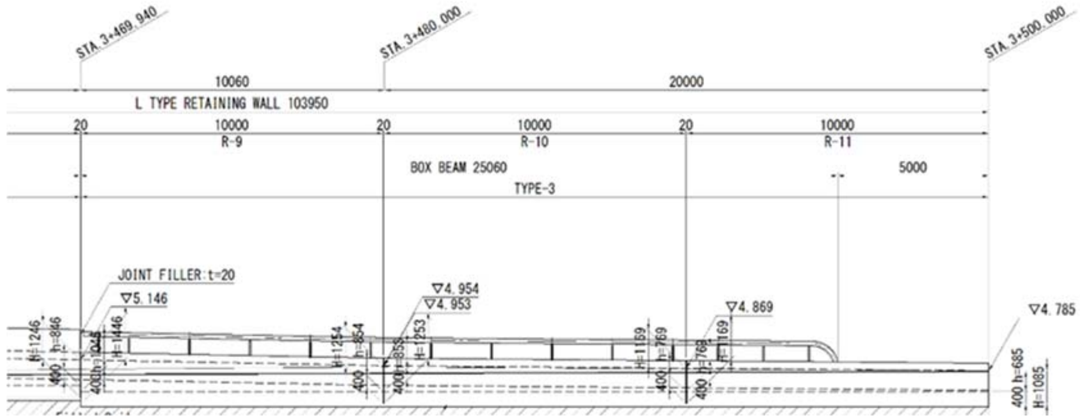


Source: JICA Study Team

Figure 3.5.15 Shape of Drainage Facility and Retaining Wall

(4) Concrete Barrier and Box Beam

A concrete barrier is basically installed in the approach section of the flyover as with the flyover section. However, a steel box beam is installed in the 30 m section before connecting to the at grade section so that enough visibility can be provided to the driver at the merging area.



Source: JICA Study Team

Figure 3.5.16 Side View of the Box Beam

3.5.6 Road Surface Drainage

The following types of drainage facilities are applied:

- Standard Section: Open channel with W:1.5 m x H:1.5-1.7 m.
- Narrow Section: Open channel with W:1.0 m x H:1.5 m.

  <= Narrowed to ensure the space for public facility installation. Necessary capacity is ensured.
- Road Crossing Section: Box culvert with W:1.5 m x H:1.5 m.
- Road Crossing Section (Small earth covering section): Box culvert with W:1.0-1.5 m x H:1.0 m.

  <= Necessary capacity is ensured.
- Mechanically-stabilized Earth Wall Section: Pipe culvert with 0.3 m diameter.
- For Road Crossings: Covered U-ditch with W:0.5 m x H:0.5 m.

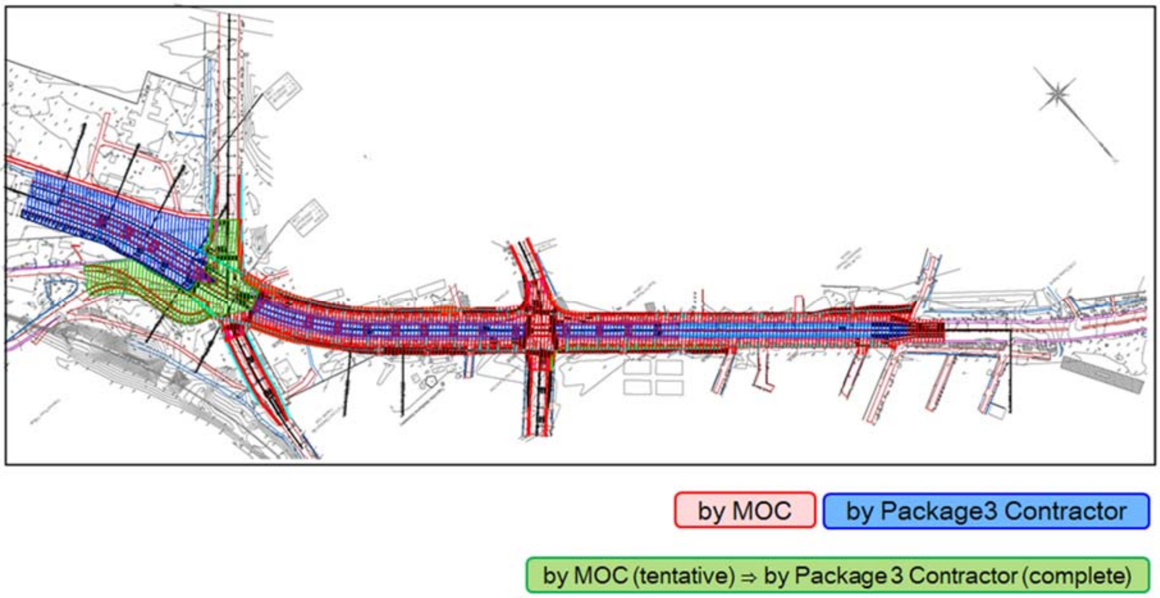
  Covered U-ditch with W:0.5 m x H:0.85 m.

  Covered U-ditch with W:0.8 m x H:0.8 m.
- Crossing Section: W:0.3 m or 0.2 m diameter.
- End of Flyover: Pipe culvert with 0.3 m diameter.

3.5.7 Demarcation between Yen Loan and Myanmar for Package 3

3.5.7.1 Outline

Construction of flyover and widening of Thanlyin Chin Kat Road were originally done by Package 3 contractor. However, in the discussion with MOC on 22th June 2017, it was determined that widening of Thanlyin Chin Kat Road shall be directly completed by MOC prior to the commencement of flyover construction by the Package 3 contractor as shown in Figure 3.5.17. In this section, design modification due to the demarcation change is introduced.



Source: JICA Study Team

Figure 3.5.17 Demarcation between Package 3 Contractor and MOC for Package 3

Detailed demarcation between Package 3 Contractor and MOC is shown in Table 3.5.3.

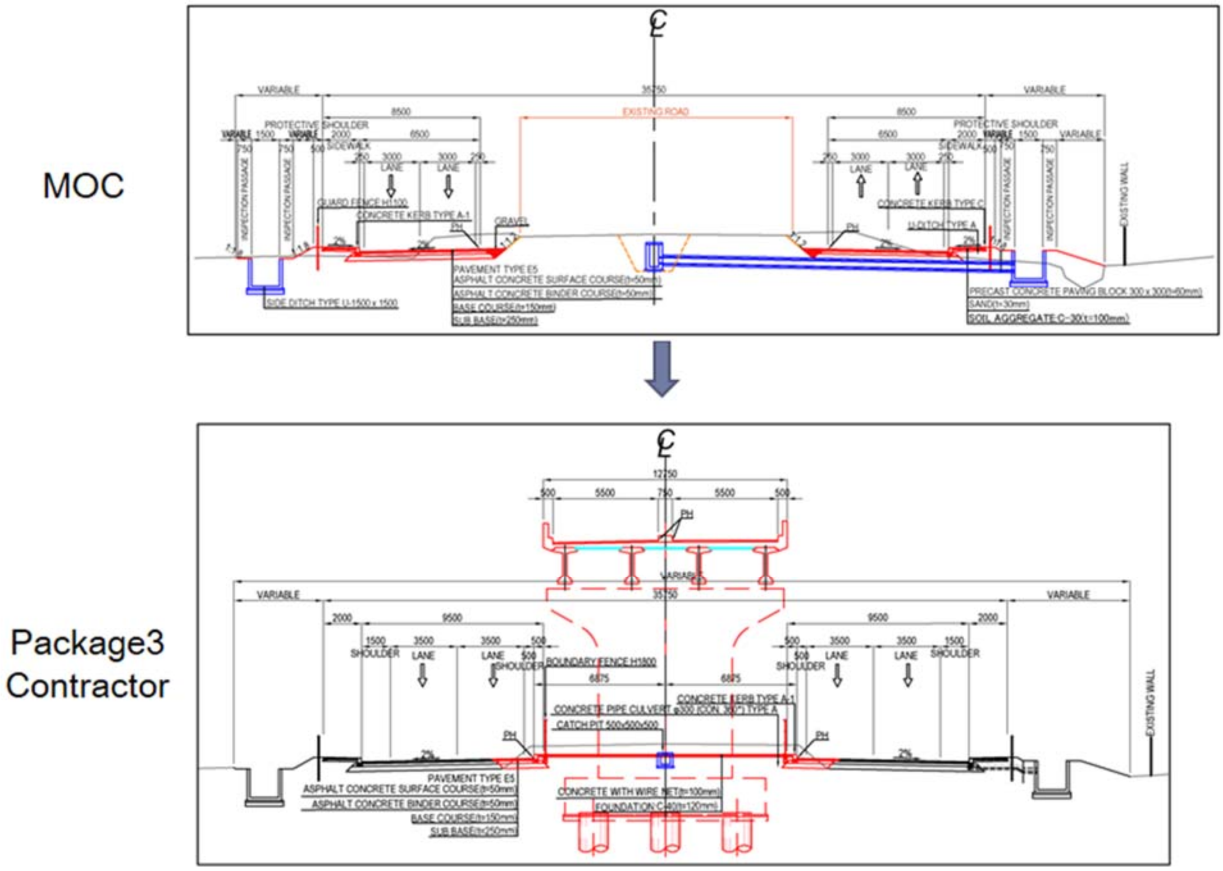
Table 3.5.3 Detailed Demarcation between Package 3 Contractor and MOC

Work Item	MOC	Package 3 Contractor
Site Clearing	➢ Outside construction yard for flyover	➢ Within construction yard for flyover
Road Works	➢ Earth Work & Pavement (6.5m) ➢ Sidewalk ➢ Intersection (Tentative) ➢ Tentative approach road to/from existing Thanlyin Bridge	➢ Earth Work & Pavement (1.5m or 2.5m) within construction yard ➢ Intersection (Complete) ➢ Approach road (Complete) to/from existing Thanlyin Bridge (Package 2)
Drainage Works	➢ Side ditches & Box culverts ➢ Concrete pipe culvert ➢ Catch pits on Thanlyin Chin Kat Rd.	➢ Bridge drainage
Miscellaneous Works	➢ Road lighting on Thanlyin Chin Kat Rd. ➢ Concrete kerb outside construction yard for flyover ➢ Road markings (Tentative) ➢ Regulation / Warning sings ➢ Traffic signals on I/S (Tentative) ➢ Guard fence on sidewalk	➢ Road lighting on Flyover ➢ Concrete kerb within construction yard for flyover ➢ Informatory sign board ➢ Road markings (Complete) ➢ Traffic signals on I/S (Complete) ➢ Boundary fence under flyover
Flyover Works	N/A	➢ Flyover Bridge ➢ Approach Road

Source: JICA Study Team

3.5.7.2 Typical Cross Section

Typical cross section for each construction stage is shown in Figure 3.5.18.



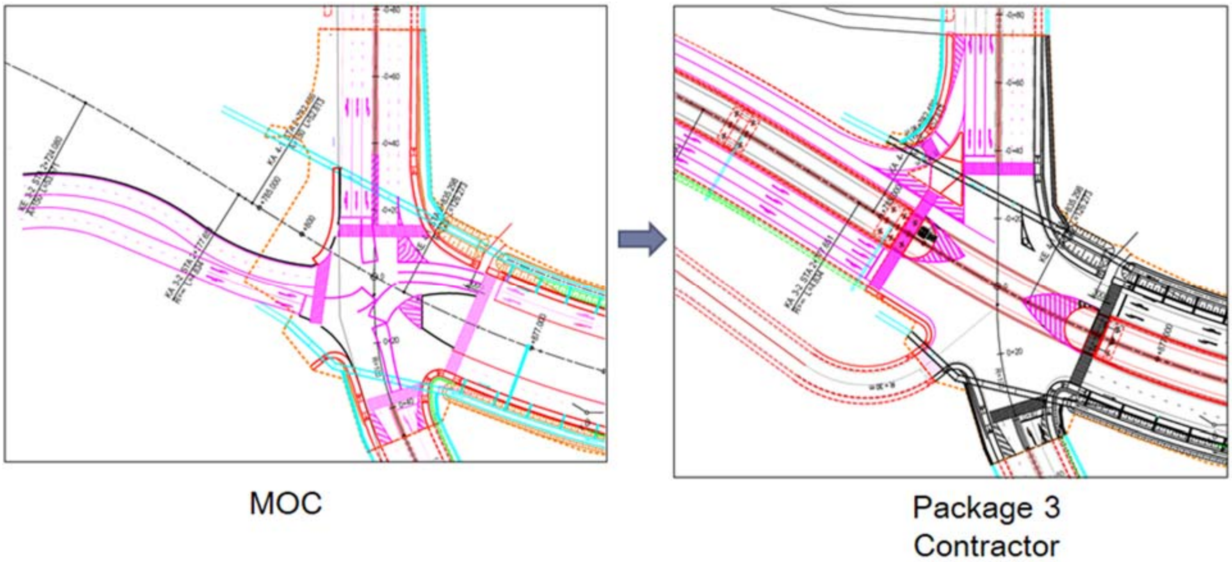
Source: JICA Study Team

Figure 3.5.18 Typical Cross Section

3.5.7.3 Intersection Design

(1) Shukhinthar Intersection

The main traffic flow generates to/from the existing Thanlyin Bridge until Bago River Bridge and flyover is completed. Therefore Shukinthar intersection and its approach road shall be tentatively adjusted for smooth traffic flow by MOC and then shall be completed after the completion of flyover by Package 3 contractor as shown in Figure 3.5.19.

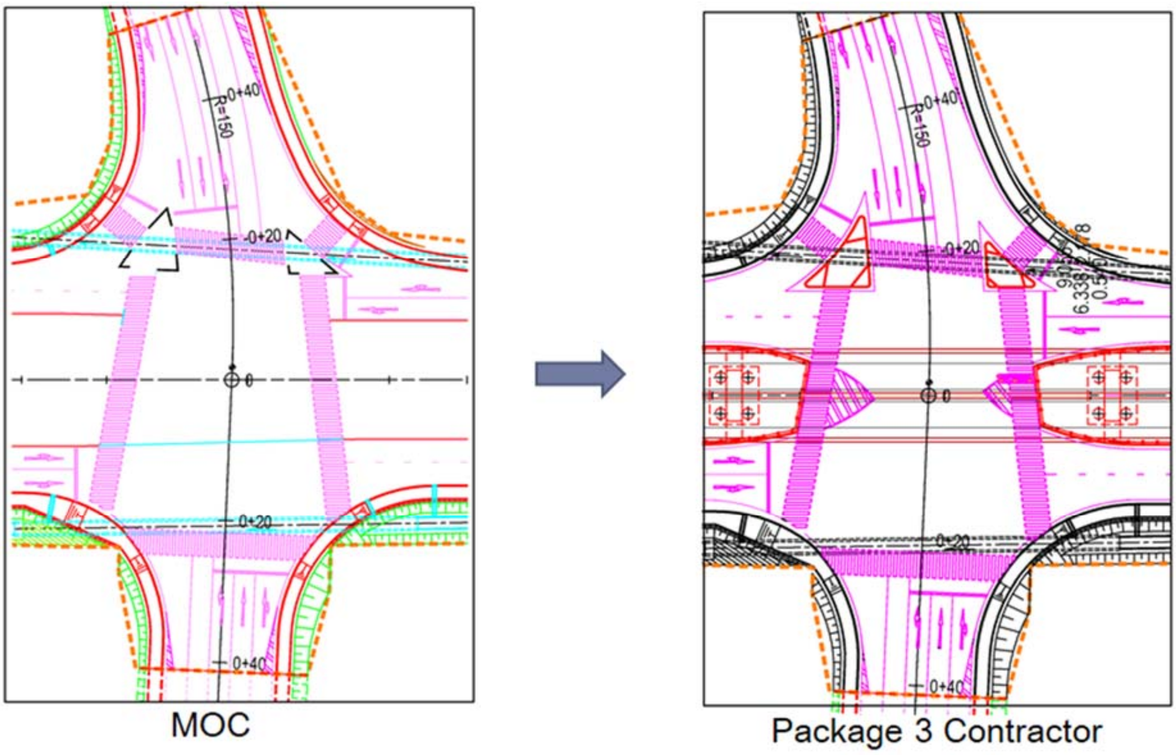


Source: JICA Study Team

Figure 3.5.19 Design Modification for Shukhintar Intersection

(2) Yadanar Intersection

At Yadanar intersection, the works except for traffic islands, road markings and medians under girders can be completed during widening of Thanlyin Chin Kat Road by MOC, and then remain works for completion shall be done by Package 3 contractor as shown in Figure 3.5.20.

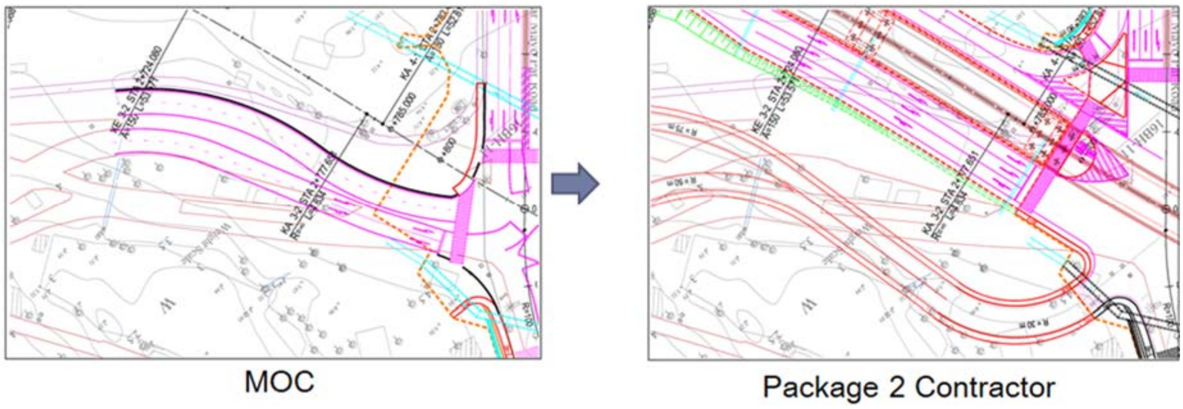


Source: JICA Study Team

Figure 3.5.20 Design Modification for Yadanar Intersection

3.5.7.4 Approach Road to / from the Existing Thanlyin Bridge

Approach road to/from the existing Thanlyin Bridge shall be adjusted in accordance with the tentative Shukinthar intersection by MOC and shall be completed by Package 2 Contractor as shown in Figure 3.5.21.

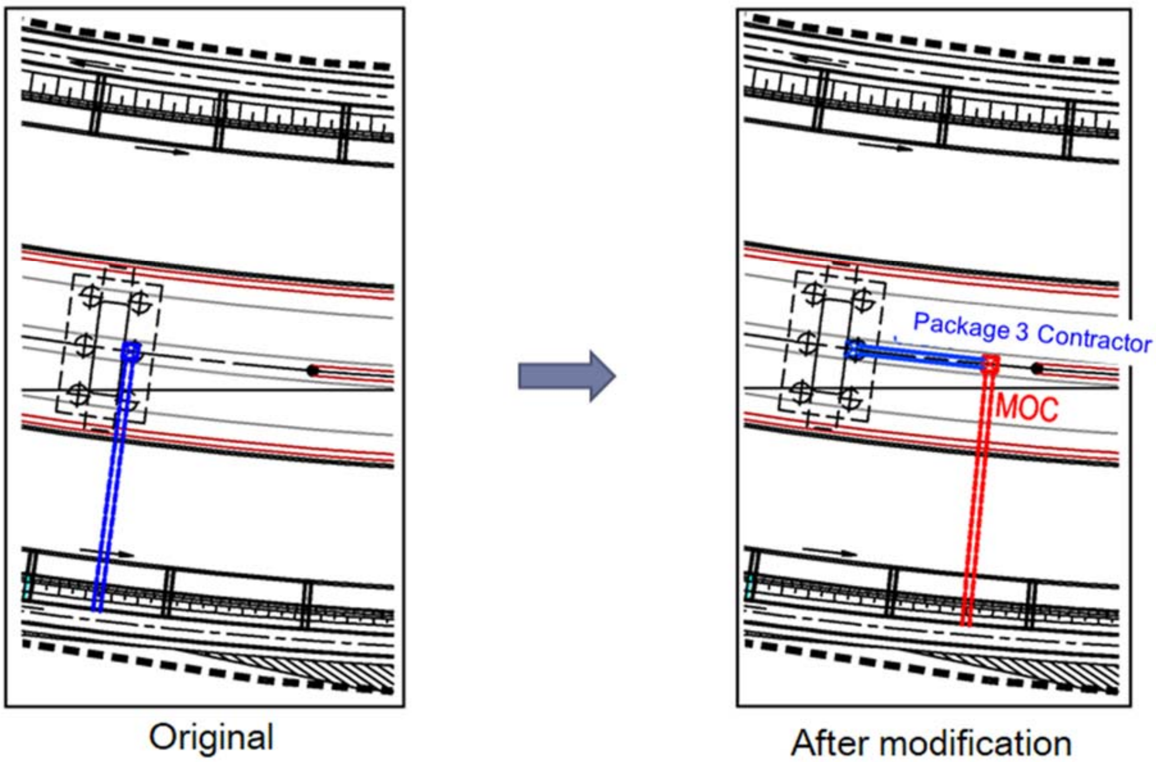


Source: JICA Study Team

Figure 3.5.21 Design Modification for Approach Road to/from the Existing Thanlyin Bridge

3.5.7.5 Bridge Drainage

The drainage system of the bridge should be changed from the initial plan in consideration of the construction order. Changes are shown in Figure 3.5.35.



Source: JICA Study Team

Figure 3.5.34 Design Modification for Bridge Drainage (Flyover).

3.6 INTERSECTION IN THANLYYIN TOWNSHIP (STA.0+040)

3.6.1 Proposed Solution on Newly-built Intersection

3.6.1.1 Propose of study

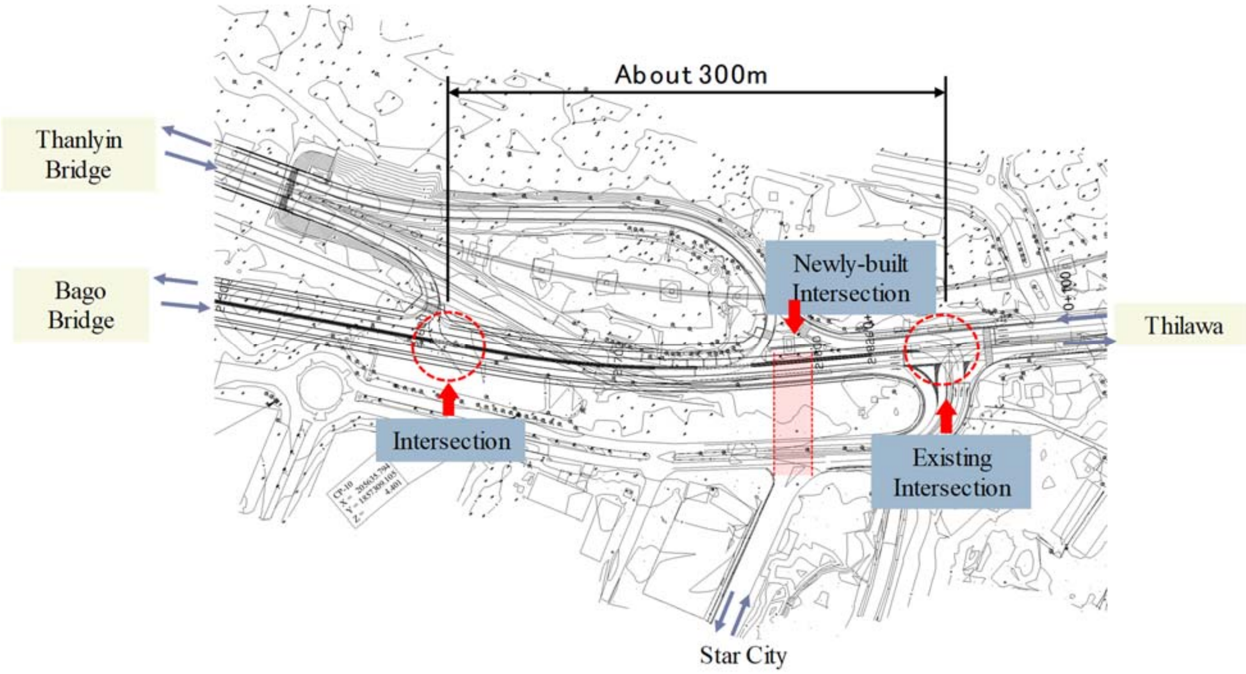
Star City intersection at STA.0+040 for access to residential complex, Star City, was newly installed at the beginning of 2017.

Source: Google

Figure 3.6.1 Location of Newly-built Intersection

3.6.1.2 Problems of Newly-built Intersection

- Too Close to Existing Intersection and Planned Intersections.
- Conflict with Traffic from/to Thilawa and Bago Bridge.

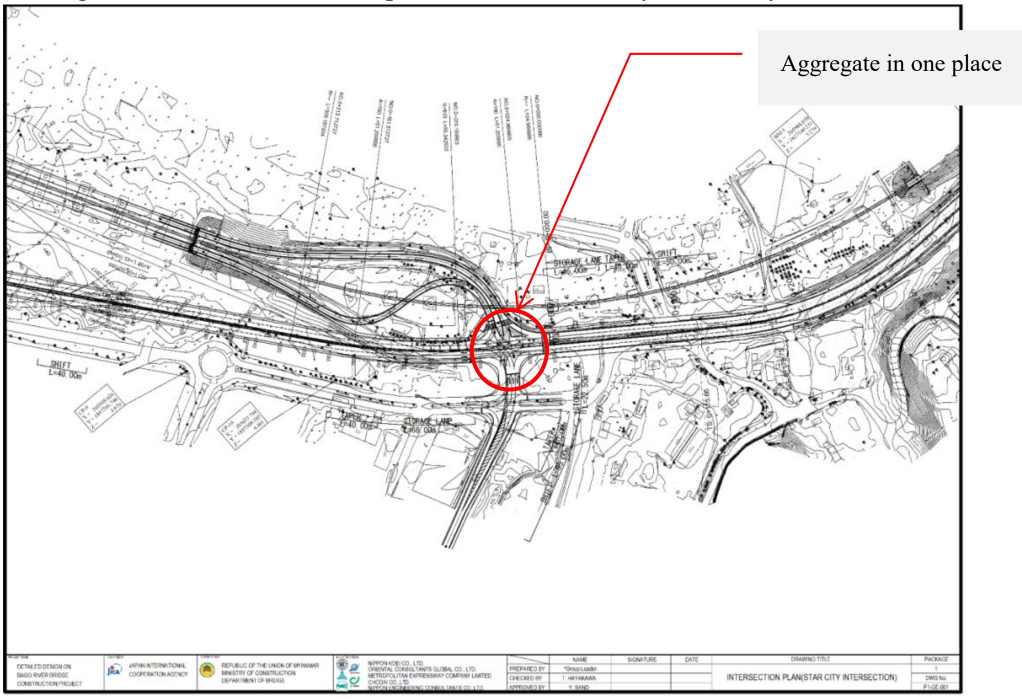


Source: JICA Study Team

Figure 3.6.2 Problems of Newly-built Intersection

3.6.1.3 Proposed Solution

- One Integrated Intersection will improve traffic efficiency and safety.

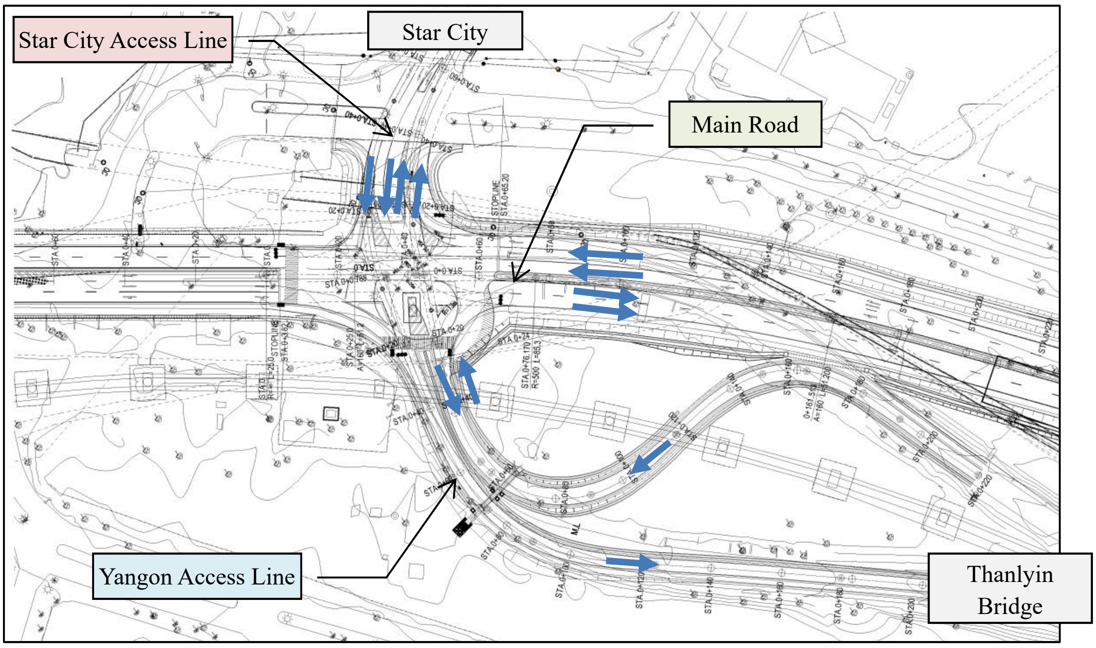


Source: JICA Study Team

Figure 3.6.3 Proposed Solution

3.6.2 Design Conditions

The name of each route is shown in Figure 3.6.10



Source: JICA Study Team

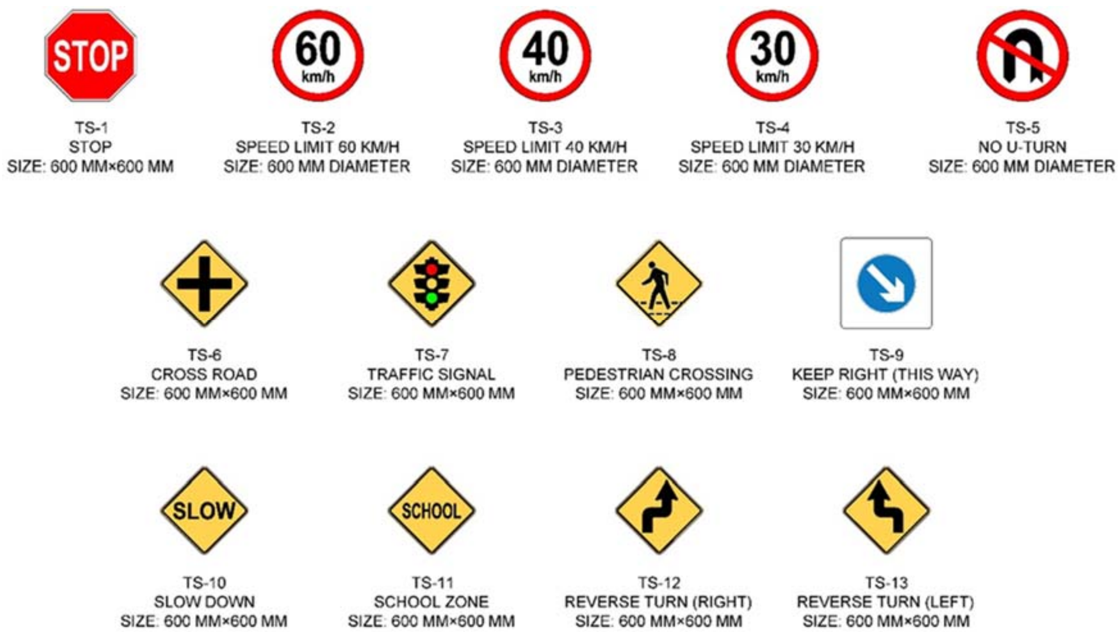
Figure 3.6.4 Name of each route

3.7 TRAFFIC SIGNS AND ROAD MARKINGS

3.7.1 Traffic Signs

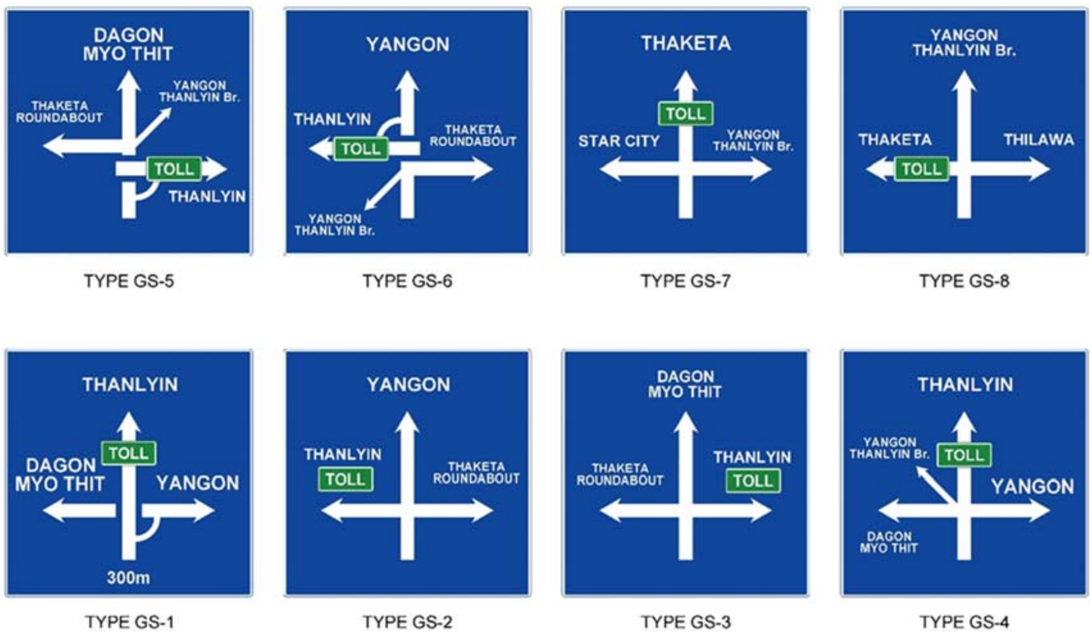
The Project will deploy traffic signs including warning signs, regulatory signs, and information signs as given in Figure 3.7.1.

In addition to the traffic signs, informatory signboards which will guide drivers on road destinations will be introduced as given in Figure 3.7.2. These signboards shall be installed at appropriate locations before the driver's entry into the major intersections.



Source: JICA Study Team

Figure 3.7.1 Traffic Signs



Source: JICA Study Team

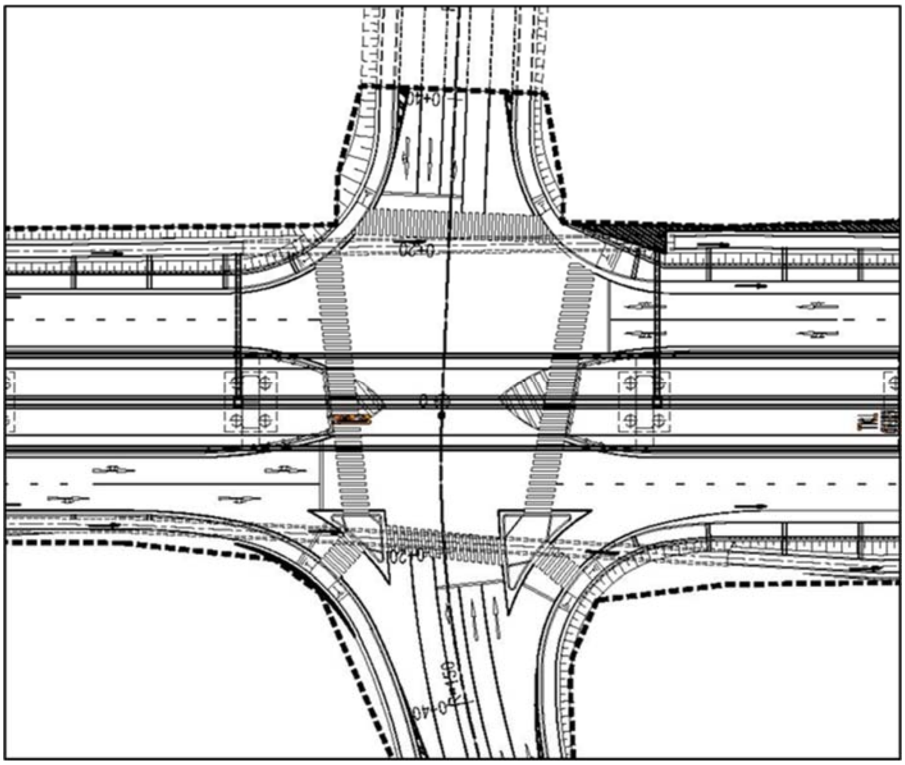
Figure 3.7.2 Informatory Signboards

3.7.2 Road Marking

In order to establish traffic safety and secure smooth traffic flow, the following road markings, among others, will be deployed in the Project:

- Arrow mark
- Zebra zone
- Stop line
- Crosswalk lines
- Lane lines
- Holding lines
- Give way lines

Figure 3.7.3, which is the plan drawing of Thanlyin Chin Kat Road - Yadanar Road Intersection, shows the example of road marking deployment in the Project.



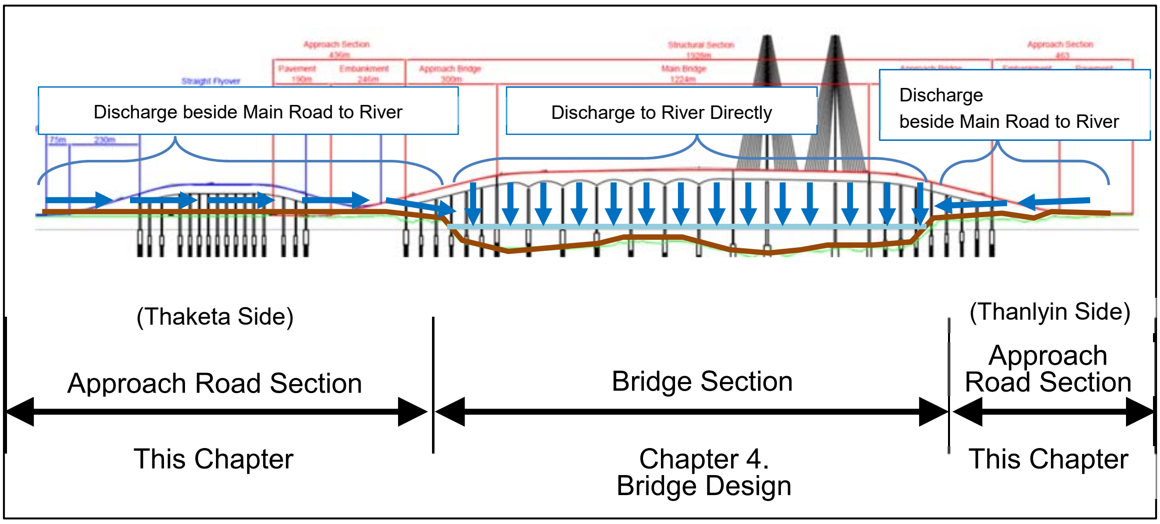
Source: JICA Study Team

Figure 3.7.3 Example of Road Markings

3.8 DRAINAGE DESIGN

3.8.1 General

Rainfall water inside the Project site will discharge to Bago River. Figure 3.8.1 shows the overall concept for drainage design. The rainfall water around approach road area will discharge through drainage structures along the Project road. In the bridge section on the river, the water will discharge directly to the river. This chapter will cover the drainage design of the approach road section only consisting of right and left river bank section and will exclude the bridge section on Bago River.

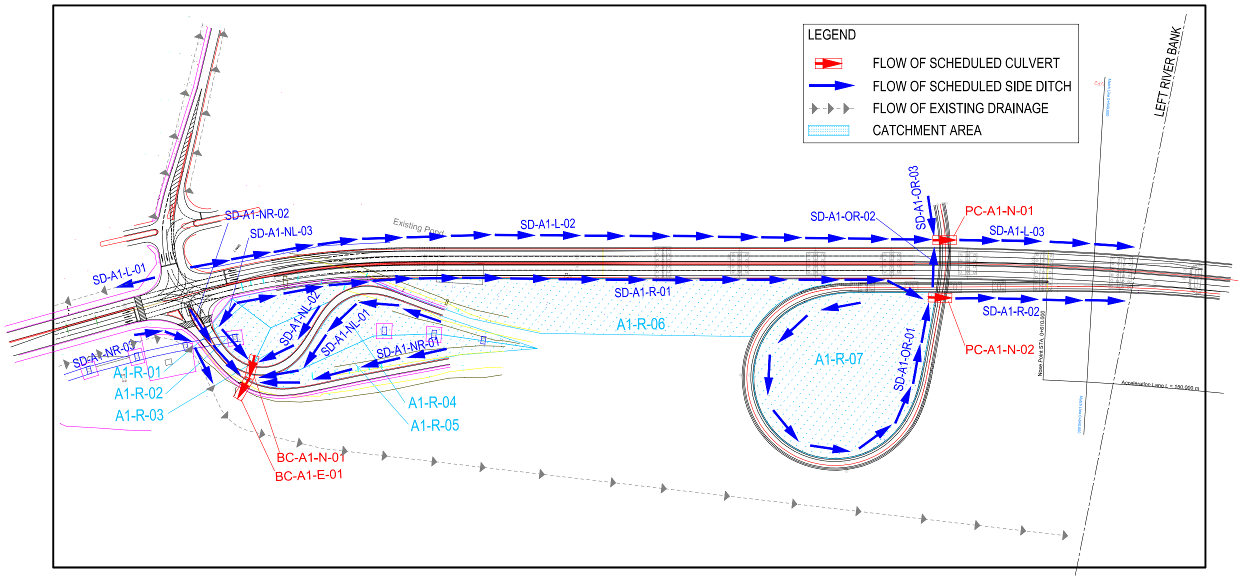


Source: JICA Study Team

Figure 3.8.1 Demarcation and Concept of Drainage Design

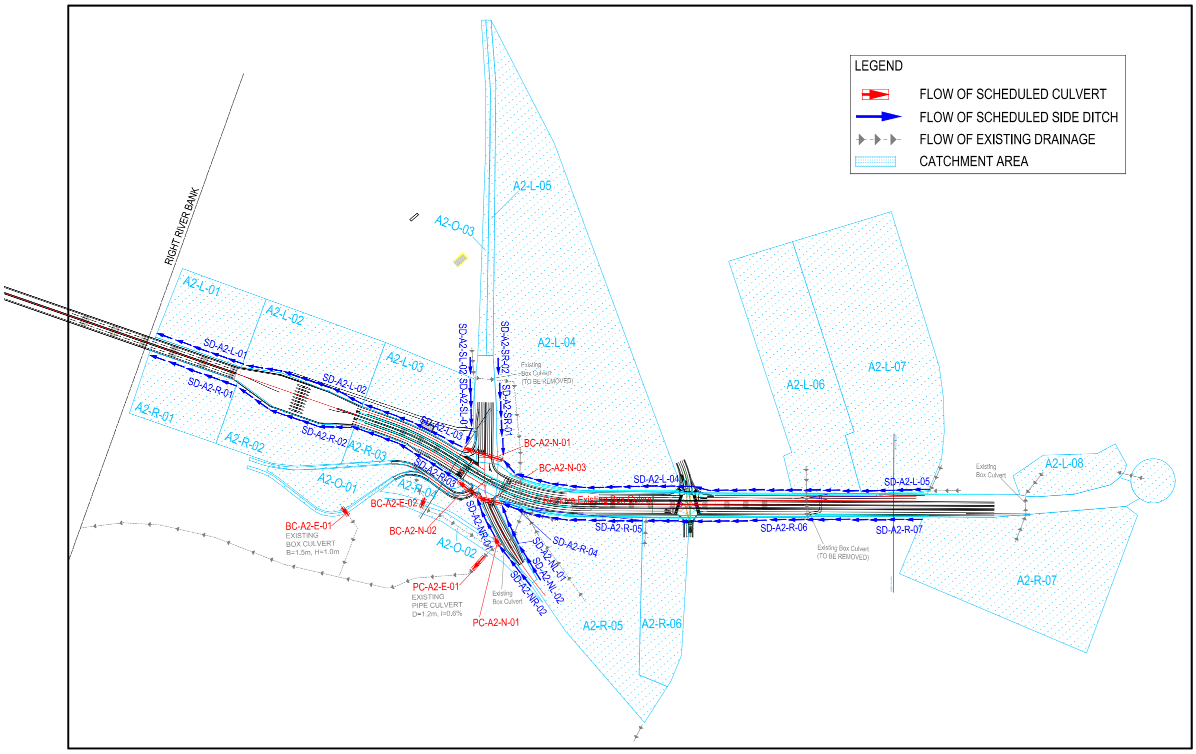
3.8.2 Drainage System and Outlets

The JICA Study Team surveyed the existing drainage system by collecting related documents, conducting site inspection and topographic survey, and through interviews with engineers from YCDC and Thanlyin Township (YRDC). The existing drainage system in the right river bank is shown in Figure 3.8.3, as collected from YCDC. On the other hand, there is no data related to the existing drainage system in the left river bank authorized by Thanlyin Township, so the JICA Study Team determined the drainage flow. i.e., from and to where the drainage should discharge, based on joint site inspection with the engineers from Thanlyin Township (YRDC).



Source: JICA Study Team

Figure 3.8.2 Catchment Area in Left River Bank (Package 1)



Source: JICA Study Team

Figure 3.8.3 Catchment Area in Right River Bank (Package 2 and 3)

3.8.3 Type of Drainage Structures and Drainage Capacity Design

3.8.3.1 Type of Drainage Structures

The types of the drainage structures to be used for the Project are listed in Table 3.8.1.

Table 3.8.1 Types of Drainage Structures

Type	Drainage Structure	Purpose
Open Ditches	Side Ditch Type U Inside Width (mm): 300, 500, 800, 1000, 1500 Height (mm): 500~2500 (Vary)	Collection of rainfall water from gutter, sidewalk, vertical drain, culvert crossing roadway and U-ditch crossing sidewalk.
	U-Ditch Crossing Sidewalk Inside Width (mm): 300 Height (mm): 150~300	Collection of rainfall water from pavement surface and crossing sidewalk
	PVC Pipe Crossing Sidewalk Inside Dia. (mm): 150 mm	Ditto
Concrete Pipe Culverts	Reinforced Spun and Centrifugal RC Pipes (Class I, Precast) Inside Dia. (mm): 300, 900 Protection with 360 Degree Concrete for joint protection	Crossing the roadway and Discharge rainfall water from paved surface along roadway
Concrete Box Culverts	Box Culvert Type Inside Width & Height (mm): 1000x1000, 1500x1000, 1500x1500	Crossing roadway
Catch Basin, Inlet, Outlet, Manholes	Catch Pit (Rectangular Type) with Concrete or Steel Grating Cover Minimum Pitch: 5 m* Maximum Pitch: 30 m*	Connection between Open Ditches, Concrete Pipe, Box Culverts, Vertical Drains
Vertical Drain	PVC Pipe Type Inside Dia. (mm): 200 mm Minimum Pitch: 10 m	Guiding the water from the roadway gutter inlet to the roadside main drainage
	U-Ditch Type Inside Width (mm): 300 Height (mm): 300~1000	Ditto
Drainage Outlet	Flap Gate with Box Culvert Type Flap Gate Width and Height (mm): 1000x1000, 2000x1500 Box Culvert: Inside Width and Height (mm) are the same as for Flap Gate	Preventing reverse water flow from river side to upsteam of drainage system; The flap gate shall be provided at the end of each drainage outlet.

Source: JICA Study Team

*Note: * In accordance with Earthworks Manual, Japan Road Association, 2009*

3.8.3.2 Schedule of Drainage

Based on the above study, the drainage type, dimension, slope rate, and bottom elevation of each drainage structure are shown in following tables.

Table 3.8.2 Schedule of Drainage (Left Side)

Package	Road	Side	Location (STA.)		Distance (m)	Type	Dimension (Width x Height)	Slope rate (%)	Drainage Bottom Elevation (Elv. m)		Concrete Cover	Remark
			B.P. side	E.P. side					B.P. side	E.P. side		
1	Main	Left	0+000.000	0+016.000	16.00	U	800x1000	0.125%	4.860	4.880	○	
			0+060.000	0+537.000	477.00	U	800x800	-0.170%	4.274	3.463	-	Along Main Road
			0+537.000	0+547.000	10.00	PC	900	-0.300%	2.720	2.690	-	Under On-ramp Rd
			0+547.000	0+640.000	93.00	U	1000x1000	-0.100%	2.690	2.597	-	To Drainage Outlet
2	Main	Left	2+240.000	2+680.992	440.99	U	1500x2500	0.080%	1.502	1.855	○	To Drainage Outlet
			2+680.992	2+775.000	94.01	U	1500x2500	0.120%	1.855	1.968	○	Along Main Road
3	Main	Left	2+775.000	2+840.000	65.00	BC	1500x1500	0.102%	1.968	2.034	-	Under Crossing Rd
			2+840.000	2+850.000	10.00	U	1500x1500	0.110%	2.034	2.045	-	Open
			2+850.000	2+860.000	10.00	BC	1500x1500	0.110%	2.045	2.056	-	Under Entrance
			2+860.000	3+060.000	200.00	U	1500x1500	0.047%	2.056	2.150	-	Open
			3+060.000	3+068.000	8.00	BC	1500x1500	0.047%	2.150	2.154	-	Under Entrance
			3+068.000	3+120.000	52.00	U	1500x1500	0.047%	2.154	2.178	-	Open
			3+120.000	3+278.000	158.00	BC	1500x1500	0.047%	2.178	2.252	-	Under Crossing Rd
			3+278.000	3+289.000	11.00	BC	1500x1000	0.330%	2.252	2.289	-	Under Entrance
			3+289.000	3+300.000	11.00	BC	1500x1500	0.220%	2.289	2.313	-	Under Side-Walk
			3+300.000	3+311.000	11.00	U	1500x1700	0.330%	2.313	2.349	○	Under Side-Walk
			3+311.000	3+330.000	19.00	BC	1500x1000	0.330%	2.349	2.412	-	Under Side-Walk
			3+330.000	3+378.000	48.00	U	1500x1700	0.330%	2.412	2.570	○	Under Side-Walk
			3+378.000	3+388.000	10.00	BC	1500x1000	0.330%	2.570	2.603	-	Under Entrance
			3+388.000	3+409.000	21.00	U	1500x1700	0.330%	2.603	2.673	○	Under Side-Walk
			3+409.000	3+434.000	25.00	BC	1500x1000	0.330%	2.673	2.755	-	Under Entrance
			3+434.000	3+455.000	21.00	U	1500x1700	0.169%	2.755	2.791	○	Under Side-Walk
			3+455.000	3+478.000	23.00	U	1500x1500	0.105%	2.791	2.815	-	Open
			3+478.000	3+483.000	5.00	BC	1500x1000	0.105%	2.815	2.820	-	Under Entrance
			3+483.000	3+540.000	57.00	U	1500x1500	0.105%	2.820	2.880	-	Open

Source: JICA Study Team

Note: U=Side Ditch Type U, PC=Pipe Culvert, BC=Box Culvert

Table 3.8.3 Schedule of Drainage (Right Side)

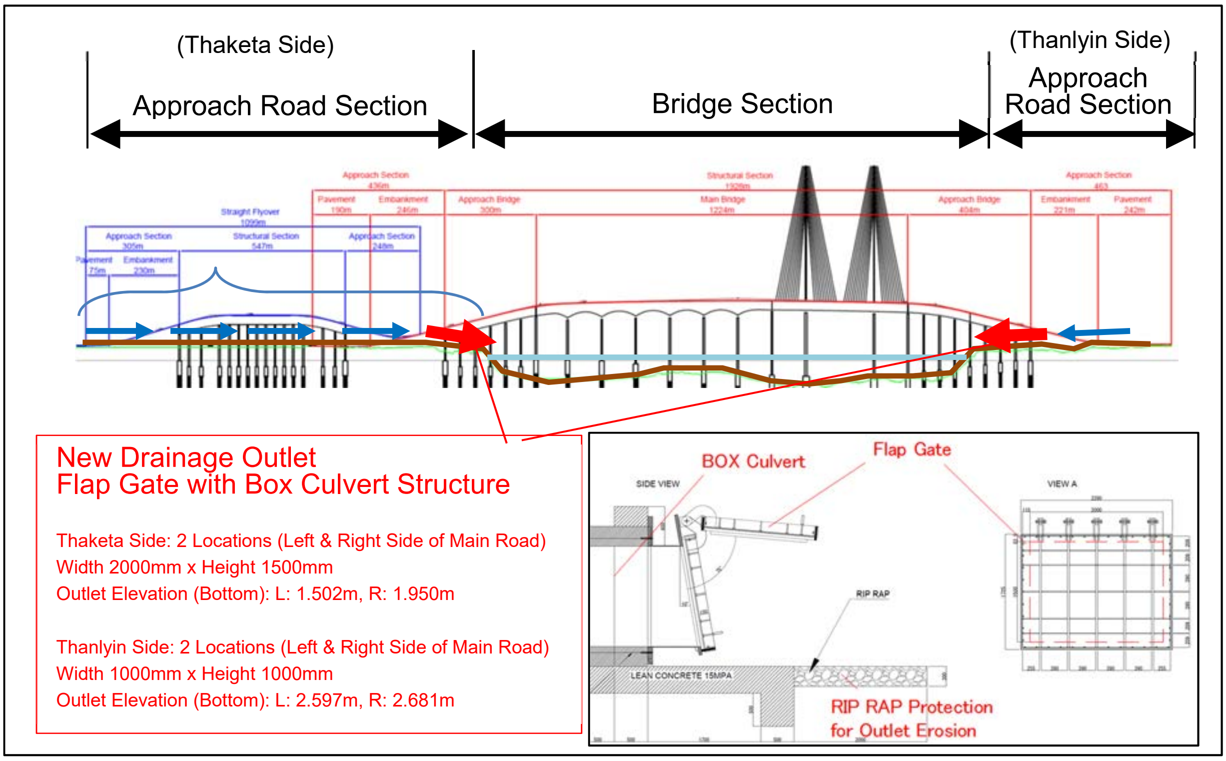
Package	Road	Side	Location (STA.)		Distance (m)	Type	Dimension (Width x Height)	Slope rate (%)	Drainage Bottom Elevation (Elv. m)		Concrete Cover	Remark
			B.P. side	E.P. side					B.P. side	E.P. side		
1	Main	Right	0+000.000	0+024.970	24.97	U	500x850	-0.577%	4.773	4.629	○	To Thanlyin Access
			0+060.000	0+165.000	105.00	U	800x800	-0.130%	4.114	3.978	○	Along Main Road
			0+165.000	0+187.000	22.00	PC	900	-0.130%	3.978	3.949	○	Along Main Road
			0+187.000	0+534.000	347.00	U	800x800	-0.130%	3.949	3.498	-	Along Main Road
			0+534.000	0+545.000	11.00	PC	900	-0.400%	2.820	2.776	-	Under On-ramp Rd
			0+545.000	0+640.000	95.00	U	1000x1000	-0.100%	2.776	2.681	-	To Drainage Outlet
	On-ramp	Right	0+000.000	0+025.900	25.90	U	300x300	-0.100%	3.500	3.474	-	Along On-ramp
			0+025.900	0+062.100	36.20	U	300x300	0.100%	3.464	3.500	-	Along On-ramp
			0+062.100	0+410.000	347.90	U	300x300	0.100%	3.292	3.640	-	Along On-ramp
2	Main	Right	2+240.000	2+620.000	380.00	U	1500x2500	0.100%	1.950	2.330	○	To Drainage Outlet
			2+620.000	2+760.000	140.00	U	1500x2500	0.050%	2.330	2.400	○	Along Main Road
			2+760.000	2+810.000	50.00	U	1500x2500	0.100%	2.400	2.450	○	Along Main Road
3	Main	Right	2+810.000	2+860.000	50.00	BC	1500x1000	0.090%	2.450	2.495	-	Under Crossing Rd
			2+860.000	2+987.000	127.00	U	1500x1500	0.028%	2.495	2.530	-	Open
			2+987.000	2+993.000	6.00	BC	1500x1000	0.029%	2.530	2.532	-	Under Entrance
			2+993.000	3+037.000	44.00	U	1500x1500	0.029%	2.532	2.545	-	Open
			3+037.000	3+043.000	6.00	BC	1500x1000	0.029%	2.545	2.546	-	Under Entrance
			3+043.000	3+080.000	37.00	U	1500x1500	0.029%	2.546	2.557	-	Open
			3+080.000	3+088.000	8.00	BC	1500x1000	0.048%	2.557	2.561	-	Under Entrance
			3+088.000	3+127.000	39.00	U	1500x1500	0.048%	2.561	2.580	-	Open
			3+127.000	3+184.000	57.00	BC	1500x1000	0.048%	2.580	2.607	-	Under Crossing Rd
			3+184.000	3+240.000	56.00	U	1500x1500	0.048%	2.607	2.634	-	Open
			3+240.000	3+247.000	7.00	BC	1500x1000	0.048%	2.634	2.637	-	Open
			3+247.000	3+301.000	54.00	U	1500x1500	0.048%	2.637	2.663	-	Open
			3+301.000	3+308.000	7.00	BC	1500x1000	0.048%	2.663	2.666	-	Open
			3+308.000	3+345.000	37.00	U	1500x1500	0.064%	2.666	2.690	-	Open
			3+345.000	3+363.000	18.00	BC	1000x1000	0.190%	2.690	2.724	-	Under Entrance
			3+363.000	3+378.000	15.00	U	1000x1500	0.330%	2.724	2.774	○	Under Side-Walk
			3+378.000	3+396.000	18.00	BC	1000x1000	0.330%	2.774	2.833	-	Under Entrance
			3+396.000	3+483.000	87.00	U	1000x1500	0.330%	2.833	3.120	○	Under Side-Walk
			3+483.000	3+499.000	16.00	BC	1000x1000	0.330%	3.120	3.173	-	Under Entrance
			3+499.000	3+517.000	18.00	U	1000x1500	0.330%	3.173	3.232	○	Under Side-Walk

Source: JICA Study Team

Note: U=Side Ditch Type U, PC=Pipe Culvert, BC=Box Culvert

3.8.4 New Drainage Outlets

The new drainage outlets planned to deal with the issues mentioned in Section 3.8.7.1 above are shown in Figure 3.8.4.



Source: JICA Study Team

Figure 3.8.4 New Drainage Outlets